Prairie Oat Growers Manual

Back, Huvenaars, Kotylak, Kuneff, Simpson, Ziesman

University of Alberta
Plant Science 499

Created by:

Barbara Ziesman
Carly Huvenaars
Joseph Back
Kim Kuneff
Krista Kotylak
Liz Simpson

Printed in 2010

Printed in Canada

To view this manual, go to:

www.poga.ca

Disclaimer

The Prairie Oat Growers Manual is a reference tool for growers of Western Canada.

The authors have tried to ensure that all information is accurate and complete, however it should not be considered as the final word in all decisions. If there is a deviation from the manual you should seek advice from a trained professional.

All the information provided is strictly for informational purposes and the authors make no guarantee on the use and reliance of the information. It is at your own personal risk, therefore the authors shall not be liable for any personal damages or losses or any theory based liability arising from use of the information provided.

Table of Contents

Acknowledgement

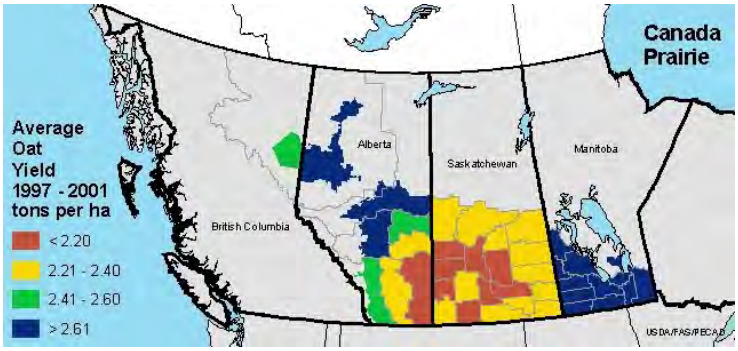
We would like to thank the following people for their contributions in creating this manual:

Miles Dyck
Llyod Dosdall
Linda Hall
Ross McKenzie
Jennifer Mitchell Fetch
Jim Unterschultz
Chris Willenborg

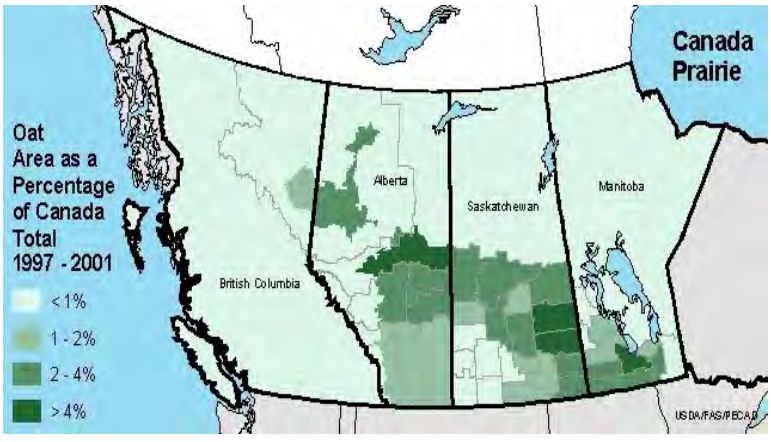
As well as a special thanks to our editors:
Emile deMilliano
John Huvenaars
Lisa Huvenaars
Bernard Kotylak
Jana Sen
Greg Stamp

Introduction

Oats (*Avena sativa* L.) are an annual cereal crop used worldwide for human and animal feed. It was first utilized as both a grain for human consumption and forage for animals in Western Europe as early as 1000 A.D. (Willenborg, 2004; McMullen, 2000). Oats are well suited for production under marginal environments (such as cool climates and soil with limiting nutrients) in comparison to other cereal crops (Hoffmann, 1995). Western Canada is suited for oat production as many oat varieties flower and mature quickly in the short season conditions.



Canadian oat production was estimated at 786 500 tonnes in 2010, with an average yield of 72.9 bushels per acre (Statistics Canada, 2010). The annual acreage of seeded oats in western Canada has increased considerably in the past three decades. Much of this is due to improved yields, grain quality, disease resistance and market demand (Willenborg, 2004). The seeded acres of oats are relatively low compared to crops like canola, wheat or barley. Government investment in oat breeding is also lower (Zechner et al. 2008). There is limited information on oat production compared to other crops.



Varieties

When choosing a variety it is important to consider its intended use, the growing area, the expected yield and any disease considerations.

- Below are compiled charts showing different varieties of milling, feed, forage and hulless oats. Milling and feed oats are the most common.
- Know the end purpose of your oats before you plant.
- Most varieties are suited for all of western Canada, however there are a few varieties such as AC Juniper, and AC Morgan that have specific growing areas.
- Yield changes by region and variety, consult the tables below to find the ideal variety for your area.

Alberta: Agronomic Crop Performance 2010

http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex4069/$FILE/cereals.pdf

Saskatchewan: Varieties of Grain Crops 2010

http://www.agriculture.gov.sk.ca/Default.aspx?DN=9d4a928f-f7f2-45c9-87af-92fb97b9c567

Manitoba: Seed Manitoba 2010

http://www.agcanada.com/seedmanitoba2010/

- Know the disease prevalence in your area and choose a variety accordingly. (See diseases)
  - Stem and crown rust are common in the wetter regions of Manitoba, there are resistant varieties available.
  - When choosing the seed be sure to choose certified seed for a guarantee of viable, clean, weed free seed, with minimal disease risk which will allow for even germination and a uniform stand.
  - Keep on top of new varieties; some to watch for are Stainless, Summit, SO-1, OT3037 (SeCan, 2010; Manitoba Co-operators, 2009).
  - Some common varieties do not have information available such as: Calibre. Summit, Stainless, and HiFi.

Milling Oats

The main use of milling oats is human consumption. It is common in cereals, soups, cookies and granola bars. Another area of use is in pet foods. If the oats do not make the milling grade, they will be downgraded to feed oats (Alberta Agriculture, Food and Rural Development (AAFRD), 2010). Milling oat quality is determined by a high groat (endosperm) content, a low hull percentage, plump heavy kernels and ideally a white hull. When selling for pony oats the white hull is preferred (Manitoba Co-operators, 2009). It is

important for milling varieties to have a low oil content as high amounts of oil can lead to spoilage (Mitchell Fetch, J., personal communication).

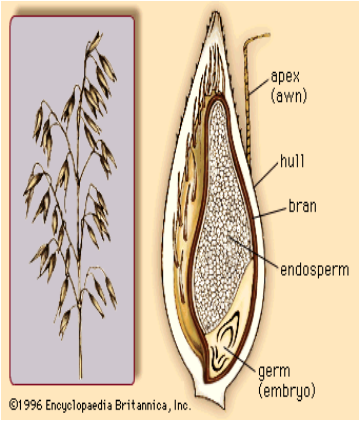


Table 1. Milling oat variety descriptions

Varieties	Purpose, Location Restrictions	Strengths	Weaknesses
7600M (2007)	Milling	Resistance to stem rust Resistance to smut rust	Late maturing Susceptible to leaf rust
AC Assiniboia (1995)	Milling Suited for rust infested areas of Western Canada	Improved Rust Resistance (to Robert)	Tan color Low Yield Susceptible to crown rust Tan hull
AC Juniper (1995)	General Purpose Suited to Alberta and Saskatchewan Short season	Early maturity High yield Stronger straw Plump kernels Lower hull content Less thin kernels Short Heavy Kernel Weight	Lower test weight *AC Juniper compared to Jasper
AC Medallion (1996)	General Purpose Suited for Western Canada	Resistance to crown rust Resistance to smut Resistance to stem rust Tolerant of BYDV High kernel weights High yielding High test weights White hull	Later maturing Weak straw strength
AC Morgan (1999)	Milling or Feed Black/Grey wooded soil zones in Alberta	Higher Yield * In suitable areas Lodging resistance Plump kernels White Hull Lower oil content *Compared to CDC Pacer	Later Maturing Susceptible to crown rust Susceptible to stem rust Moderately susceptible to Smut *Compared to CDC Pacer

AC Pinnacle (1999)	Milling or Feed Suited for Western Canada	Higher Yield Resistance to crown rust Moderate resistance to BYDV White hull Plump kernels * Compared to Derby	Later Maturing Susceptible to crown rust
AC Preakness (1993)	General Purpose Suited for Manitoba and Saskatchewan	Resistance to rust White hull Lodging resistance	Later maturing
AC Rebel (1996)	General Purpose Suited for non rust areas in Western Canada	High Yield Resistance to BYDV Resistance to smut Resistance to stem rust Resistance to most crown rust (not Pg9) Lodging resistance High kernel protein	Later maturing High hull percent Less plump kernels
CDC Boyer (1994)	General Purpose Suited for non rust areas in Western Canada	Early maturity Plump Kernels High groat yield	Lower test weight Susceptible to smut.
CDC Dancer (2000)	Milling Suited for non rust areas in Western Canada	Low hull percent (20%) High yield High test weight Plump kernels Low percent thins Strong straw Early maturity Resistance to smut	Susceptible to crown rust
CDC Orrin (2001)	Milling Suited for non rust areas in Western Canada	High Yield High test weight Large kernel size Plump kernel Low percent thins Resistance to smuts	Susceptible to crown rust Susceptible to stem rust
CDC Pacer (1996)	Milling Suited for non-crown rust areas in Western Canada	Early maturity High Yield *compared to Derby Resistance to smut Plump kernels	Susceptible to BYDV Susceptible to crown rust
CDC Weaver (2004)	Milling Suited for Western Canada	High Grout yield High milling yield Plump kernels High kernel weight Resistance to smut Resistance to crown rust	Some lodging Medium/tall height

Derby (1988)	General Purpose Milling Long growing season Non-rust areas	Low hull content High Test weight Plump Kernels High yield	Late Maturing Susceptible to rust Susceptible to smut Weak straw
Furlong (2003)	Milling Feed Suited to Western Canada	Lodging resistance High yield Resistance to stem rust Resistance to smut	Small kernel size Lower test weights Later maturing * Compared to CDC Dancer Brown Hull Susceptible to crown rust
Jasper (1985)	Milling Non rust areas Short season	Early maturing High Protein High oil content Low hull content High test weight Sprouting resistance	Susceptible to lodging Susceptible to crown rust Susceptible to stem rust Susceptible to loose smut
Jordan (2007)	Milling	Heavier kernel weight Resistance to BYDV High spikelets /head White/gold hull	Late maturing Tall Hull pinches off seed, reducing seed size
Kaufmann (2001)	Milling Rust prone areas and black soil zones in Manitoba and Saskatchewan	High Yielding Plump kernels High test weight High groat content High yield Resistance to crown rust Resistance to stem rust Resistance to smut Semi-resistant to BYDV White Hull	Later maturing *compared to CDC Pacer Susceptible to stem rust NA67
Leggett (2004)	Milling Suited for Western Canada	Resistance to crown rust Resistance to smut Resistance to stem rust Plump kernels Good yield in rust areas	Late maturity Lower groat yields
OT 566 (2004)	Milling Suited for Central and Western Canada	High test weight High kernel weight Plump kernels High groat protein Resistance to smut Moderate resistance to stem rust	Susceptible to lodging Tall Susceptible to crown rust Susceptible to BYDV

Ronald (2002)	Milling Suited for Black soil zones Manitoba and Saskatchewan Rust infected areas	Plump Kernels Lodging resistance Low hull percent High yield Resistance to stem rust Resistance to crown rust Resistance to BYDV Resistance to smut White hull Semi-dwarf	Moderate maturity Susceptible to stem rust race NA67
Triple Crown (1997)	Multi-Purpose Suited to non-rust areas in Alberta and Saskatchewan	High yielding Resistance to crown rust Moderate resistance to smut White hull	Later maturity High hull content Susceptible to BYDV Susceptible to stem rust
OT3037 (2010)	Milling Suited for Western Canada	High yield Large grain Plump kernels Resistance to crown rust Resistance to stem rust White hull	Susceptible to stem rust Moderate susceptibility to BYDV
OT3044 (2010)	Milling Suited for Western Canada	High beta-glucans High protein Strong straw Resistance to crown rust Resistance to stem rust BYDV tolerant	Smaller kernels Lower Yield

(AAFRD, 2010a; Manitoba Co-operator, 2009; Saskatchewan Ministry of Agriculture, 2010; SeCan, 2006a; SeCan, 2006b; SeCan, 2006d; SeCan, 2006f; University of Saskatchewan (U of S), 2010c; U of S, 2010e)

Feed Oats

Feed oats are used to feed cattle and other livestock. They commonly have a higher hull content around 22-27%, which is ideal for ruminant animals (AAFRD, 2010a). In a feed oat a high hull content and low lignin is ideal (Mitchell Fetch, J., personal communication). An ideal variety is Hi-Fi as it is high in beta-glucan and fiber (Manitoba Co-operator, 2009). Pony oats belong to a specialized feed market; consisting of a lower hull percentage, white hulls and low acid content, targeting easy digestibility. An ideal variety is Hi-Fi as it is high in beta-glucan and fiber (Manitoba Co-operator, 2009). An upcoming variety to look for is CDC SO-I.

Table 2. Feed oat variety descriptions

Variety	Purpose Location Restrictions	Strengths	Weaknesses
AC Mustang (1994)	Silage and Forage	5-7% high yield than Cascade Lodging resistance High percent of plump kernels Low percent of thin kernels Heavy test weight	Susceptible to crown rust Susceptible to stem rust Unsuitable for milling
Cascade (1979)	Feed oat Focus is in the moist areas of Western Canada	Older variety, but high yielding Early maturing Strong straw Low shattering High hull content	Susceptible to crown rust Susceptible to stem rust Susceptible to smut Low percent of plump kernels.
Lu (2001)	Feed oat Non rust areas and black soil areas of Saskatchewan and Alberta	Very Early maturing High Yield Lodging resistance High test weight White hull High hull content	Susceptible to crown rust Susceptible to stem rust Moderately susceptible to smut Moderately susceptible to barley yellow dwarf virus Low milling opportunity
Waldern (1990)	Feed oat High Moisture Areas	High Yield Plump kernels Lodging resistance Shattering resistance High hull content	Late maturity Susceptible to rust Susceptible to smut Low test weight
Athabasca (1978)	Feed oat Short growing season in Grey soil zones	Early maturing High Hull content	Low yielding Shattering
Bia (2004)	Western Canada	Shattering resistance Drought Tolerance Lodging resistance Resistant to cereal cyst nematode	Moderately susceptible to loose smut Moderately susceptible to covered smut Moderately susceptible to stem rust Moderately susceptible to crown rust Moderately susceptible to red leaf rust Late maturing (105 days)
SW Triactor (2009)	Feed oat White oat for potential sale into the Pony market.	High Yielding Lodging resistance White oat Moderate resistance to crown rust Moderate resistance to smuts	
CDC SO-1 (2010)	Feed oat Western Canada	Low acid detergent lignin in hull High oil content High yield Early maturing Resistance to smut High kernel weight	Susceptible to crown rust

CDC SOL-FI (2010)	Feed oat Western Canada	High beta-glucans Low fat percentage High protein Early maturing Tolerance to BYDV	Susceptible to Crown rust Susceptible to stem rust Lower Yield Susceptible to Lodging Low groat %
OT3039 (2010)	Feed oat Western Canada in non-rust areas	High yield Low Acid Detergent lignin in hull High groat fat % Tolerance to BYDV	Late maturing Low test weight Thin seed size Susceptible to crown rust Susceptible to stem rust

(AAFRD, 2010a; Manitoba Co-operator, 2009; Manitoba Agriculture and Food Rural Initiative (MAFRI), 2001; Saskatchewan Ministry of Agriculture, 2010; SeCan, 2006c; U of S, 2010a; U of S, 2010b; U of S, 2010d)

Forage Oats

Forage oats produce a large amount of biomass, as all of the above ground plant material is utilized. If not harvested for forage, these varieties will have a low seed yield (AAFRD , 2010a).

Table 3. Forage oat variety descriptions

Variety	Purpose, Location Restrictions	Strengths	Weaknesses
CDC Baler (2000)	Forage		Susceptible to smut
CDC Bell (1998)	Forage		
Foothill (1978)	Forage Foot hills of Alberta *Highest yield in the west central foothills.	20% more digestible dry matter compared to Fraser	Lower grain yield
Murphy (2001)	Forage	Higher Yield than Foothill in forage and grain yield High protein Lodging resistance	Later maturity Susceptible to smut

(AAFRD, 2010a; Manitoba Co-operator, 2009; Saskatchewan Ministry of Agriculture, 2010; SeCan, 2006e)

Hulless Oats

Hulless oats still have a hull, but it is loosely attached to the seed. During harvest the hull comes off and the groat is then fed to humans and animals (AAFRD , 2010a). In general the yields are lower

than the feed oat variety Cascade. Hull removal is the main reason why yields are low, there is a decrease in weight from 5 to 25% (MAFRI, 2001). There are special management considerations when seeding hulless oats, (see weeds). When choosing to grow hulless varieties it is safer to ensure that you have a contract before planting (Manitoba Co-operators, 2009).

Table 4. Hulless oat variety description

Varieties	Purpose Location Restrictions	Strengths	Weaknesses
AC Belmont (1992)	Hulless Suited for Alberta	Improved disease resistance from Terra High percent of non-hulless kernels	Low yield Late maturity Susceptible to crown rust Itchy to handle
AC Boudrias (2000)	Hulless Suited for Western Canada	High yield Lodging resistance High test weight Plump kernels Crown rust resistance Improved BYDV resistance	Late maturity High hull content
AC Gwen (2000)	Hulless Suited for Western Canada	High yield High groat yield Plump kernels Less thin kernels Higher Thousand Kernel Weight Resistance to crown rust Resistance to BYDV Resistance to smut	Later maturity Susceptible to stem rust (Race NA67)
Bullion (1999)	Hulless Specialty markets Suited for Western Canada	High grain protein (4-5% higher) High test weight	Susceptible to BYDV Susceptible to crown rust Susceptible to stem rust Susceptible to smut
Lee Williams (2002)	Hulless Suited for Western Canada	High yielding Heavy kernels Plump kernels Less thin kernels Crown rust resistance	Low test weight Low groat content

- **Variety strengths & weaknesses in relation to AC Belmont**

(AAFRD, 2010a; Manitoba Co-operator, 2009; Saskatchewan Ministry of Agriculture, 2010)

Yield Components

Fertility

Growth and development of oats is heavily dependent on the fertility of the soils. Therefore adequate crop nutrition is critical. The fertility recommendations provided are generalized, and should coincide with soil testing, which is the best way to gain awareness of the fertility levels of individual fields.

Fertility Recommendations : N, P, K, S

Soil samples give the best indication of the nutrients present in the soil and should be involved in all fertility planning. Local agronomists or programs such as AFFIRM, Alberta Farm Fertilizer Information and Recommendation Planner, are valuable resources for fertility planning.

AFFIRM can be downloaded at :

http://www1.agric.gov.ab.ca/$department/softdown.nsf/main?openform&type=AFFIRM&page=download

Macronutrients

The four macronutrients needed for plant growth are nitrogen, phosphorus, potassium and sulphur (N-P-K-S). Macronutrients are needed in large quantities for plant growth.

Table 5. The amount of macronutrients (in kg/ha) removed from the soil by an oat crop (84 bu/ac).

Crop	Crop Part	N	P	K	S
Oats	Seed	58	24	17	8
	Straw	40	15	70	10
	Total	98	39	87	18

(Western Canada Fertilizer Association, 2002)

Nitrogen

Nitrogen fertility recommendations are directly dependent on:

- Stored soil moisture (SSM)
- Growing season precipitation (GSP)
- Available soil N

To determine the SSM you can use a soil moisture probe, or use a projected average for your area.

Determining N requirement in the Brown soil zone:

- *With 2" of SSM + 6" of GSP then soil N + fertilizer N apply 60 lb/ac (67 kg/ha)*
- *With 4" of SSM + 6" of GSP then soil N + fertilizer N apply 75 lb/ac (84 kg/ha)*
- *With 6" of SSM + 6" of GSP then soil N + fertilizer N apply 90 lb/ac (100 kg/ha)*

Determining N requirement in the Dark Brown soil zone:

- *With 2" of SSM + 8" of GSP then soil N + fertilizer N apply 70 lb/ac (78 kg/ha)*
- *With 4" of SSM + 8" of GSP then soil N + fertilizer N apply 85 lb/ac (95 kg/ha)*
- *With 6" of SSM + 8" of GSP then soil N + fertilizer N apply 100 lb/ac (112 kg/ha)*

Determining N requirement in the Black soil zone:

- *Typically moisture is not a limiting factor therefore optimally, soil N + fertilizer N should equal 100 lb/ac (112 kg/ha)*

Determining N requirement in the Grey/Grey Wooded Soil Zone:

- *2" SSM N + fertilizer N should equal 80 lb N/ac (90 kg/ha)*
- *4" SSM N + fertilizer N should equal 100 lb N/ac (112 kg/ha)*
- *6" SSM N + fertilizer N should equal 112 lb N/ac (135 kg/ha)*

A higher rate of nitrogen will typically result in a reduction of seed quality. If the oats are for feed, higher rates are favorable to increase tillering and biomass production.

Phosphorus

- Medium phosphorus levels are 30-55 lbs/ac (34-62 kg/ha) at a 6" sample depth (McKenzie and Middleton, 1997).
- Soil test readings below 30-55 lbs/ac (34-62 kg/ha) indicate the need for phosphorus application to restore to an acceptable level.

Table 6. Soil test ratings for available phosphorus.

Soil test level rating	Phosphorus (P) (lb/ac)
Very low	0 - 20
Low	20 - 35
Medium * Acceptable levels	35 - 50
High	50 - 80
Very high	80

(McKenzie and Middleton, 1997)

Potassium

- Optimal level is 290 kg/ha (250 lbs/ac)
- If soil sample shows below 290 kg/ha (250 lbs/ac), restore to an acceptable level.

Table 7. Soil test ratings for available potassium and recommended application rates.

Soil Test K (lb/ac in 0-6 in. depth)		Recommended Application Rate (lbs/ac)
0-50		75
51-100	Very Deficient	60
101-150		45
151-200	Moderately Deficient	30
201-250		15
251-300	Marginal	0
301+	Adequate	0

(AARD, 2000)

Sulphur

- Optimal level is 22 kg/ha (20 lbs/ac)
- If a 12" soil sample shows sulphur levels below 22 kg/ha (20 lbs/ha) restore to an acceptable level (McKenzie, R., personal communication).

Plant-Nutrient Interactions

Nitrogen (N)

- Nitrogen is the primary nutrient necessary for growth and yield.
- The appropriate nitrogen application is a balance between quality and yield. As nitrogen is increased, there will be declines in kernel weight, test weight and percent plump kernels (Marshall et al. 1987, Jackson et al. 1994, May et al. 2004).
- For seed production, nitrogen application above the optimal level can increase lodging because more nitrogen is utilized for biomass production, making the plants taller and with a greater number of tillers (Dyck, 2010).
- Higher rates of nitrogen achieve high biomass as opposed to seed yield, which is beneficial in a livestock operation (Saskatchewan Ministry of Agriculture, 2009).
- Plants absorb nitrogen in the form of ammonium and nitrate which only accounts for 2 % of the soils total nitrogen (Dyck, 2010). Fertilizers reduce this limiting factor.
- Estimated Nitrogen Release (ENR) by organic matter in Alberta has been predicted throughout the growing season for the following soil types:

Table 8. Estimated Nitrogen Release by organic matter in various soil types

	Cultivated Soil (lbs/acre)	
Soil Test Area	Mean	Range
Brown Soil	28	27 – 29
Dark Brown	34	30 – 42
Black	50	35 – 72
Dark Grey NE, SW	40	38 – 42
Dark Grey (Peace)	37	30 – 48

(Campbell et al. 1997; Jalil et al. 1996)

- Nitrogen is prone to losses through various processes such as leaching and erosion (McKenzie, 2006).
- There are soil and climatic factors that will increase the amount of nitrogen lost (McKenzie, 2006):
  - *High soil pH*
  - *Saturated soils*
  - *Dry soil surfaces*
  - *Soil temperatures above 5°C*
  - *Sandy soils*

Placement

- Oats are the most tolerant of the prairie cereals to seed placed nitrogen (Saskatchewan Ministry of Agriculture, 2009)
- Up to 45 lbs/ac (50kg/ha) of N can be placed in the seed row under adequate moisture and soil texture conditions (McKenzie, 2006).
- Anhydrous ammonia should never be placed where it can come into contact with the seed.
- As nitrogen is mobile in the soil, placement close to the seed is not essential but in severely deficient soils, it can be beneficial (Saskatchewan Ministry of Agriculture, 2009).
- Granular fertilizer can be either applied in the seed row, or banded as a separate furrow.
- Use seed band application rather than broadcast method as placing N on the surface of the soil makes it prone to losses (Dyck, 2010).

Deficiency Symptoms

Nitrogen is mobile in the plant, deficiency symptoms will be seen as yellowing first on older leaves and later on new growth. N deficient stands will appear stunted with reduced vigour

Nitrogen deficient oats.

Phosphorus (P)

- Phosphorus is the second most limiting nutrient to nitrogen.
- Phosphorus is responsible for cell division and growth in the first four weeks, and eventually yield formation (Saskatchewan Ministry of Agriculture, 2006; Grant et al. 2001).
- Phosphorous is available to plants as a soluble form (Saskatchewan Ministry of Agriculture, 2006).
- An actively growing oat crop can only absorb only about .89lbs/ac (1 kg/ha) of P per day (Mackenzie and Middleton, 1997).

- Unabsorbed P becomes less available to plants, but can be converted when necessary (Mackenzie and Middleton, 1997).
- Phosphorus has low mobility in the soil and does not leach like nitrogen or sulfur (Saskatchewan Ministry of Agriculture, 2006).
- Phosphorus is influenced by soil temperature and moisture, therefore the yield benefit may vary.
- In wet cool springs there will be an increased crop response (Mackenzie and Middleton, 1997).

Placement

- Early season availability of phosphorus and close seed placement is critical for the growth of oat seedlings especially within the first 5
- weeks. (McKenzie, 2006)
- Up to 50 lbs/ac (56 kg/ha) of phosphate can be placed with the seed on fine to medium textured soils (McKenzie, 2006).
- Phosphorus can also be banded near the seed row, but no further than 1.5 inches from the seed (McKenzie, 2006).
- Split application combines a band and seed row application. It involves an application of about 20 lbs/ac (22 kg/ha) of phosphate with the seed, and the rest as a band to avoid seed injury (McKenzie, 2006).

Deficiency Symptoms

Phosphorus is mobile within plants and therefore deficiency symptoms will appear first on tips of older leaves, base of the stem and will work its way up the plant. Purpling and browning will occur with eventual die back of the leaves (McKenzie and Middleton, 1997).

Phosphorus deficiency symptoms

Potassium (K)

- Potassium is involved in the regulation of water balance, nutrient and sugar movement and drives starch and protein synthesis (Saskatchewan Ministry of Agriculture, 2008).
- Potassium is immobile in the soil (McKenzie, 2006).
- The most abundant form of potassium is the ionic form, is removed by plants.
- It is unique, because most of it remains in the straw (Saskatchewan Ministry of Agriculture, 2008).

- Studies show no benefit to adding potassium on soils that are not deficient (Mohr et al. 2007).
- Potassium also plays an important role in maintaining straw strength preventing lodging (AAFRD, 2008).

  Lodging has the potential both to slow harvest of the crop, and to reduce yield and quality (Mohr et al. 2007).

Placement

- Potassium is relatively immobile in the soil. It is less mobile that nitrogen and more than phosphorus (McKenzie, 2006).
- Due to its relative immobility, banded methods are recommended.
- Placing the potassium next to seed can prevent water uptake by the seed due to its high salt index (Dyck, 2010).

Deficiency Symptoms

Since potassium has mobility within the plant, symptoms can appear on both the older and actively growing leaves. Symptoms include burning or scorching of lower leaves beginning at leaf tip and continuing down the leaf margin. Plant stand will appear stunted; have delayed maturity and be more susceptible to lodging. Potassium deficiency is most often found on light textured, alkaline, poorly drained or high organic soils. This deficiency is not common in prairie soils (AAFRD, 2000).

Potassium deficiency symptoms.

Sulfur (S)

- Sulfur is required for protein synthesis and the formation of chlorophyll (Eriksen and Hall, 2000).
- Required ratio between nitrogen and sulfur is 10:1 (Saskatchewan Ministry of Agriculture, 2009).
- Oats do not have as large of demand for sulfur as canola.
- An oat crop yielding 100 bushels will utilize 12-14 lbs/ac (13-16 kg/ha) (Saskatchewan Ministry of Agriculture, 2009).

- There is high oil content in the groat and sulfur is essential for oil synthesis (Saskatchewan Ministry of Agriculture, 2009).
- Sulfur is not always available in the soil for plants to uptake. It has high mobility in the soil and is prone to leaching below the root zone (Eriksen and Hall, 2000). Especially in the Grey Wooded, Thin Black, and Black soils.
- Sulfate is the plant available form.
- Organic matter contributes to soil sulfate levels, therefore low OM soils and coarse textured soils such as sand, have a high potential for sulfur deficiency.

Placement

- For sulfate application, use side banded or seed placement to locate it near the plant root zone, just before uptake (McKenzie, 2006).
- Elemental sulfur should be applied by broadcast in early fall, as it takes longer to convert to sulfate.

Deficiency Symptoms

Sulfur is not mobile within the plant. The symptoms will be concentrated on the newly emerging leaf tissue, because the youngest leaves cannot acquire the nutrient from the older leaves. Sulfur deficiency is usually detected as discoloration or yellowing on hilltops and sandy knolls across the field. (Eriksen and Hall, 2000).

Micronutrients in Oats

Micronutrients are essential nutrients that are required in trace amounts. Oats remove chlorine, copper, iron, manganese and zinc. Micronutrient deficiencies are not common, but can be diagnosed by a soil test or plant tissue analysis, when suspected. Deficiency symptoms tend to occur in irregular patches within the field, rather than cover the entirety of the field (McKenzie, 1995). Application rates are minimal, but can still have a significant impact on overall yield.

Table 9. The micronutrients used by the grain and straw of oats (kg/ha)

Harvested Crop Portion	Chlorine Removed (Cl)	Boron Removed (B)	Copper Removed (Cu)	Iron Removed (Fe)	Manganese Removed (Mn)	Zinc Removed (Zn)
Grain	1	--------	<0.1	1.00	0.20	0.10
Straw	1	-------	<0.1	0.20	0.20	0.40

(McKenzie, 1992)

Soil Factors Affecting Micronutrient Availability

- **Soil organic matter**: Soils with both low organic matter (<2%) or extremely high organic matter (>30%) have less micronutrient availability.
- **Soil texture**: Clay (fine texture) is less likely to have micronutrient deficiencies compared to sand (course texture).
- **Soil temperature and moisture**: Cool wet soils reduce the rate and amount taken up by plants.
- **Soil pH**: As pH increases, the availability decreases (Exception: Molybedum) (McKenzie, 1992).

Copper and manganese deficiencies are most common. The focus will be on these two nutrients, there role in the oat plant, identifying these deficiencies, and application methods to prevent or correct the problem.

Manganese (Mn)

- The primary function of manganese in plants is its involvement in the photosynthetic reaction in the production of oxygen (Marschner, 1995).
- Oats are the most susceptible of the cereal crops (McKenzie,1992).
- Manganese deficiencies are rare and isolated within the prairies (McKenzie, 2010).

Effects on Oats

Manganese is partially mobile in oats (McKenzie, 1992), setting it apart from the other cereals. Symptoms will spread from the older to the youngest leaves. Grey to white specks will begin to form in the leaf crease, this is known as “Grey Speck.”

The condition known as “grey speck”

Application Methods

Oats require above 1 ppm of soil manganese (McKenzie, 1992). If levels are below this, a seed placed application of manganese sulphate (26 % manganese), is needed, as broadcast application is rarely effective (McKenzie, 1992).

A foliar application can be applied if deficiency symptoms are observed. This should be done at the tillering to flag leaf stage (McKenzie, 2010).

Copper (Cu)

- Copper is involved in photosynthesis (Haehnel, 1984). About 70% of copper is found within the chlorophyll of the plant (Solberg et al. 1995).
- Among the cereals, oats is not the most susceptible to copper deficiency;
  Winter Wheat > Spring Wheat > Barley > Oats > Triticale > Rye
- High organic matter soils (peat) have the highest incidence of copper deficiency (Solberg et al. 1995).
- High nitrogen levels delay the movement of copper from old leaves to new growth, which magnifies the effects of the deficiency (Solberg et al. 1995).

Effects on Oats

There can be a 20% yield loss without showing any visual symptoms (Solberg et al. 1995). Copper does not have movement within the plant, so older leaves can remain relatively healthy, and the youngest leaves will show deficiency symptoms (McKenzie, 1995). Symptoms occur as limpness or wilting, leaf tips turn white and roll, commonly referred to as “pigtailing,” poor seed set and uneven stand maturity.

Application Methods

Soil test levels at or above 1.0 ppm copper do not require application (Solberg et al. 1995).

The most common applications is to broadcast copper sulfate (bluestone) at a rate of 3-7 lb/ac (3.4-7.8 kg/ha) (Solberg et al. 1995; McKenzie, 1995). Copper should be broadcasted alone, as it tends to collect moisture, and is difficult to blend with other fertilizers (Solberg et al. 1995). Copper will be maintained for approximately ten years (McKenzie, 1995). Copper does not move in the soil, if there is decreased soil moisture, copper will remain at the surface and will not impact crop growth (Solberg et al. 1995).

A foliar application of copper sulfate can be applied at the late tillering stage if needed (Solberg et al. 1995). This is done by

spraying at 0.1 to 0.3 lbs/acre (0.11 -0.34 kg/ha) (Solberg et al. 1995). If deficiencies are severe, a second application may be needed at the early boot stage (Solberg et al. 1995). Overall, oats are considered to have a moderate response to copper fertilization on copper deficient soils, making it less responsive than wheat or barley (Solberg et al. 1995).

Using Manure as a Source of Fertilizer

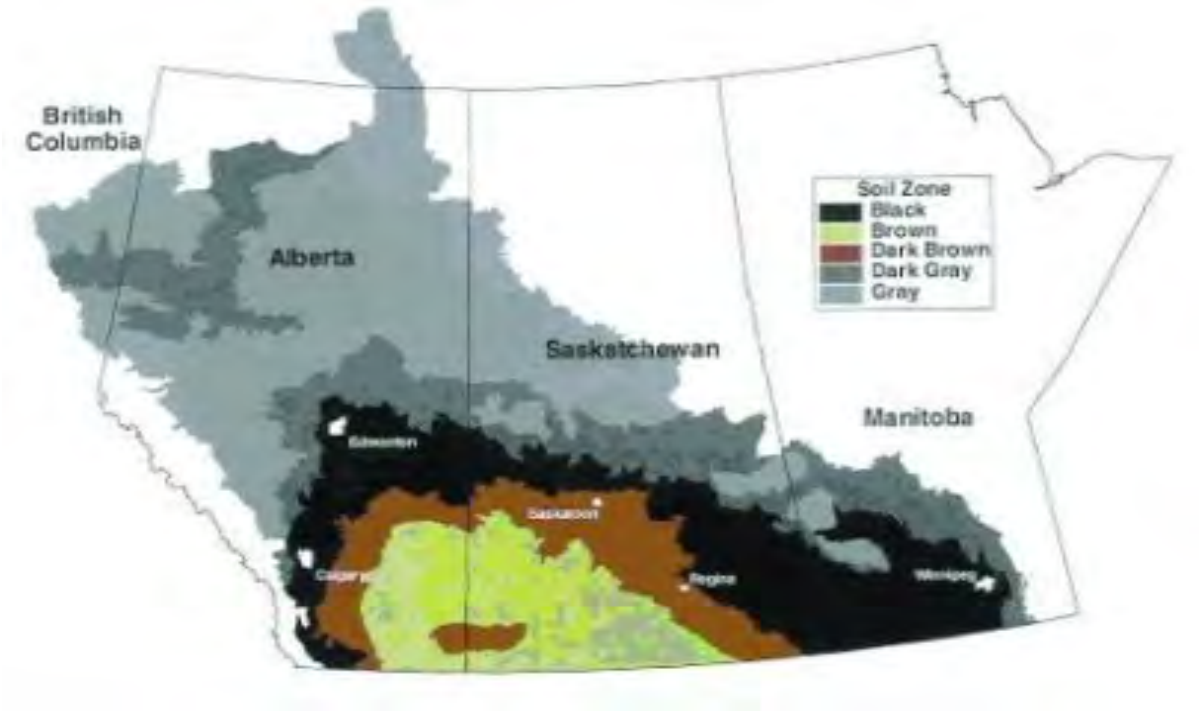
Manure application is an excellent management tool for producers integrating their livestock operation and crop production. There are challenges in terms of preserving air, soil and water quality (Tri-Provincial Manure Application Guidelines). The balance and coverage of nutrients is never even. The Tri-Provincial Manure Application and Use Guidelines Manual is available at http://www.gov.mb.ca/agriculture/livestock/beef/pdf/baa08s01a.pdf and contains information on the management principles of manure application.

Climate

- **High soil moisture**: Oats require more moisture than the other cereals (McLeod, 1982) and are less drought resistant than barley, rye or wheat (Miller, 1984).
- **Extreme Temperatures:** Oats are susceptible to damage by hot dry weather especially in the reproductive phase (Stokopf, 1985). A temperature of -2 °C is required to kill an oat seedling (AAFRD, 2002).
- **Growing Season**: Oats generally require 100-103 days to mature (MAFRI, 2010).

Optimal Soil Conditions For Oats

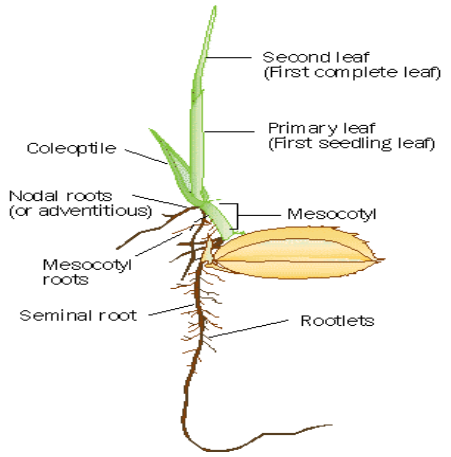
- Oats yield the best in the Black and Grey Wooded soil zones, due to their higher moisture content (Saskatchewan Ministry of Agriculture, 2009).
- Oats is the most tolerant crop to acidic soils:
  oats> flax>canola>wheat>barley
  (AAFRD, 2004).
- Micronutrient toxicities can occur at a pH below 5 (Evans, 2003).
- Oats has moderate salt tolerance being able to withstand 4-8 EC ds/m (AAFRD, 2001)



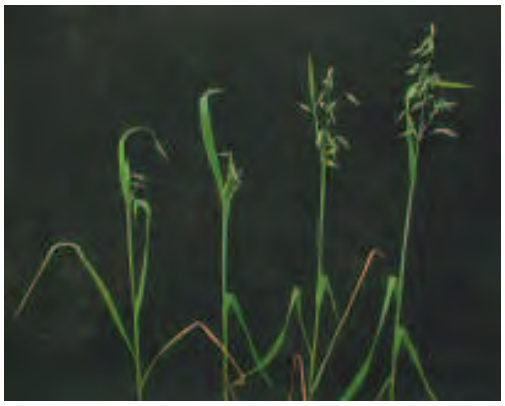
Growth and Development

Recognizing the stages of plant development is an important aspect of crop management. This can aid in the decisions of when to apply crop inputs such as fertilizer or pesticides and allows for prediction of when to harvest the crop. It can also be useful in disease and insect management.

Table 10. Stages of development following the Zadoks Growth Scale.

Growth Stage	Description	Scouting Guide
Germination 	-When conditions are optimal, the radicle root emerges from the seed. -Seminal roots extend and join the radicle to become the primary root system. -A coleoptile emerges, which surrounds and protects the first leaf.	-Soil borne diseases -Frost -Herbicide residues - Insect feeding from wireworms and cutworms
Seedling Growth 	-The first leaf emerges from the coleoptile and further leaf staging is counted from the main stem of the plant (Bayer Crop Science, Unknown). -A new leaf is counted when 50% of the leaf has unfolded (Nelson et al. 1995)	-Soil borne diseases -Frost -Herbicide residues - Insect feeding from wireworms, cutworms

Tillering 	-The first tiller will arise from the first leaf axil on the main stem and so on. -Tillers have a sheath called the prophyll, which encloses the base of the tiller (Nelson et al. 1995). This is an important factor to distinguish the leaves from the tillers.	-Timing for herbicide applications -Evaluation of pest pressure: -Major diseases: Crown rust, Barley Yellow Dwarf Virus, Septoria Insects: Cereal Leaf Beetle, Aphids -Oats can be grazed for forage when it reaches 10 inches.
Stem Elongation 	-The period of internode elongation -Each elongation node becomes progressively longer and will eventually lead to head emergence (Nelson et al. 1995). -The flag leaf is the last leaf to emerge before the head (Nelson et al. 1995). It contributes to at least 75% of the photosynthetic requirements for seed fill (Nelson et al. 1995).	-Fungicide application should occur at the flag leaf stage -Diseases such as stem and crown rust -Insect scouting for aphids and cereal leaf beetle -Peak production for forage typically runs from July 15-Aug 1, prior to panicle development.
Booting 	-This is observed by the swelling of the stem as the head is developing. -This stage is complete when the panicle is first visible at the flag leaf collar.	

Inflorescence Emergence 	-When the spikelets and panicle are visible from the flag leaf collar.	-Disease: smut, fusarium -Insect: aphids
Anthesis 	-This is the flowering stage of a plants lifecycle. -Oats is self-pollinated, similar to barley (Stoskopf, 1985).	Disease: smut, fusarium -Insect: aphids
Milk Development 	-When the oat kernel is squeezed a milky fluid comes out of the developing kernel.	-Aim for 40-60% moisture level when cutting for green feed.

Dough Development 	**Soft dough stage**: No milky liquid in the kernel, consistency of dough. **Hard dough stage**: 30% seed moisture content	-Apply pre-harvest glyphosate application prior to 30% moisture -Swath oats at the 35% moisture stage when panicles are yellow and brown, stems may be green.
Ripening 	-At maturity the peduncle (portion below the panicle head) has lost all color. -Glumes no longer green, but the lower portion stem may be still green.	-Must be less than 14% moisture at the time of combining, ideally 12% for safe storage.

Weed Management

Reducing weed populations in oat crops can have a significant impact on crop yields (AgCanada, Unknown). Management practices increasing oat competitiveness will aid in weed control. Weed management in oats is similar to barley, however with increased chemical restrictions

Managing wild oats, foxtail barley and volunteer cereals is the most significant challenge. Oat plants are physiologically similar to wild oats, which makes them equally susceptible to grass herbicides. Integrated weed management practices can be utilized to reduce the pressure of grassy weeds, as well as broadleaf weeds.

Integrated Weed Management

Pre-seeding

- Field choice:
- choose a location that has minimal existing wild oat/foxtail barley pressure.
- Avoid following a cereal crop to reduce the amount of volunteers and cereal diseases present.
- Manure placed on fields should be composted for at least a year to reduce weed seed viability.
- Seed into a clean field – remove any early weeds (Hall, 2004).

Seeding

Seed choice:

- Choose certified seed with weed and disease guarantees
- Choose seed with minimal wild oat inclusions.
- Plant seed with high seed vigor to increase crop competition.
- Select a highly competitive variety for your area (Hall, 2004).

Seeding Management

- Target high plant populations.
- Seed early, before weeds emerge.
- Selectively placed fertilizer ie. deep banding (See Fertility).

In Crop

Early weed removal

- Yields are maximized when weeds are removed early.
- Can be sprayed as early as the two leaf stage (AAFRD, 2010)

Weed Control Methods

Herbicides

- Oats are more sensitive to herbicides than other cereals.
- Tolerance will vary oat variety, type of herbicide, rate of herbicide and environmental conditions (Government of Western Australia, 2006)
- Only broadleaf herbicides can be used in crop. See provincial agricultural website for a complete list of registered herbicides:
    - Alberta
    - Saskatchewan
    - Manitoba
- Earlier maturing varieties and hulless plants can be more prone to herbicide injury (Lanoie, N., et al 2009).
- Products containing 2,4-D cannot be sprayed on oat crops. It is important to check product labels for crop safety before applying (Duffield, K. personal communication).
- Dicamba, and MCPA can reduce oat yield (Lanoie, N., et al 2009).
- Spray timing should depend on both weed infestation and crop staging (See staging guide). Early weed removal has been shown to significantly reduce yield losses.

Pre-Seed Burn-off

- Pre-seeding application of a glyphosate (i.e Round Up™) will remove early weed pressure.
- Adding a broadleaf herbicide will help reduce the risk of glyphosate resistance and aid in control of broadleaf weeds (Government of Western Australia, 2006).
- Pre-seed burn-off is the most effective way to control grassy weeds in an oat crop.
- Plan to spray the field as close to seeding as possible or immediately after to give germinating oats the competitive advantage.

Tillage

- Tillage stimulates the germination of more weed seeds by warming the soil and adding air. It is suggested that pre-seeding tillage

be avoided so wild oats will not germinate at the same time as the tame oats.

- Harrowing after oat emergence may reduce weed populations such as green foxtail if done at the appropriate time (Saskatchewan Ministry of Agriculture, Unknown).

In- Crop Yield Reducers

Wild Oat and Green Foxtail Control:

Post-harvest wild oat control can be achieved through soil applied herbicides such as Avadex™ or ethafluralin (Edge™). This provides a moderate suppression of wild oat germination the following spring. Edge™ can control emerging green foxtail. Soil applied grass herbicides have the potential to thin out / injure cereal crops and should never be applied prior to seeding a tame oat crop (AAFRD, 2010).

Wild Oats (*Avena fatua*):

Very similar in genetics and physiology to oats. There is no in-crop chemical control available that will not harm tame oats.

Requires multiple cultural control methods to reduce populations.

Appearance

Wild oats are very similar to tame oat plants, however the seeds have protruding long black awns (Saskatchewan Ministry of Agriculture, Unknown).

Green Foxtail (*Setaria viridis*):

A common grassy weed that is difficult to remove in-crop. Similar cultural control methods to wild oats are used to reduce in-crop populations. (Saskatchewan Ministry of Agriculture, Unknown).

Appearance

Green foxtail is a bunch-grass with flat leaves and a cylindrical head (Saskatchewan Ministry of Agriculture, Unknown).

Chemical Control

Products like Linuron™ or Lorox™ can be sprayed in crop if they are mixed with MCPA providing green foxtail suppression.

Spraying these products may cause injury to oats. (AAFRD, 2010)

Post Harvest:

Perennial Control:

When using glyphosate as a desiccant in the fall, increased rates can be used to control hard to kill perennial weeds such as Canada thistle, sow thistle and quack grass. Dandelions are best controlled after the first frost (Duffield, K. personal communication)

Broadleaf Control:

The addition of a residual broadleaf herbicide with glyphosate (i.e PrePass™) can provide fall and spring control of emerging broadleaf weeds.

- Note: this cannot be applied the fall when considering to plant a broadleaf crop the next season (AAFRD, 2010)

Diseases

Fusarium Head Blight (Scab)

A fungal disease that is known to affect oats as well as other cereals (Bailey et al., 2003). The causal agent can be one or a complex of several *Fusarium* species, with *Fusarium graminearum* being the most common. Yield losses may be in the form of poor seed fill, floret sterility or impaired seed germination (Bailey et al. 2003). Fusarium head blight (FHB) is difficult to detect in standing oat crops. The major problem is the presence of mycotoxins on harvested seeds (Tekauz et al., 2004). Deoxynivalenol or DON is the most common mycotoxin and is a risk to human and animal health, and can result in a lower grading (See grading).

FHB is of highest concern in Manitoba and Saskatchewan with limited economic importance in Alberta (Tekauz et al. 2008). This disease is most common in the black soil zone, associated with high rainfall. The spread of disease is assisted by rainfall during crop flowering but can also occur via wind and planting of infected seed (Canadian Grain Commission, 2010).

Table 11. Disease life cycle of Fusarium Head Blight

Spring	Summer	Fall	Winter
Over-wintering structures on stubble begin producing fungal spores. Disease pathogen can also be introduced on infected seed.	Spores are spread by wind and rain to infect healthy flowering plant and disease symptoms appear. Infection is favored by prolonged warm, moist weather during anthesis (flowering)	Over wintering structures are produced near the base of the plant.	Over winter on crop stubble.

(Bailey et al., 2003; AAFRD, 2009)

Symptoms

Infected oat panicles display premature bleaching of one or more spikelets. The hulls of infected florets may be ashen grey with characteristic pink discoloration (Bailey et al. 2003).

Management

- Tillage reduces the inoculum present in the field by turning infected residue under ground.
- Crop rotation of two to three years between cereal crops will reduce inoculum in the field. Oats should not be seeded into corn stubble or near infected crops as fungal spores can be spread by wind.
- Control of alternate hosts (barnyard grass and quackgrass) will reduce the fungal spores that can move into the oat field.
- Seed early maturing varieties to escape critical infection periods (AAFRD, 2009).
- Scouting should be done July- August (Tekauz et al., 2009a).

Crown Rust (Leaf Rust)

Is a fungal disease of oats. The causal agent requires a living plant to grow and reproduce and has variable ability to cause disease.

This disease is of highest economic importance in Manitoba and Saskatchewan occurring occasionally in Alberta. Yield losses can be up to 100% if infection is early and conditions are favourable (Bailey et al., 2003). Oat kernels of infected plants are thin with low-test weights that reduce milling qualities (Bailey et al., 2003).

Infection is favoured by humid, windy weather with temperatures ranging from 10 - 20°C (MAFRI, Unknown a).

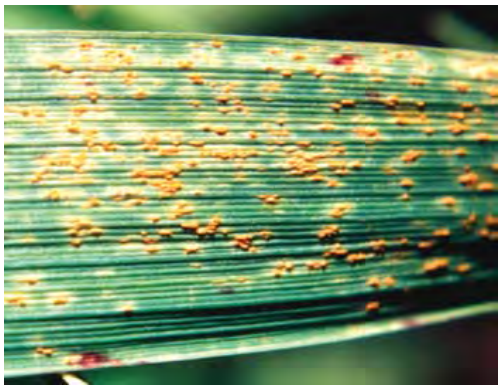
Table 12. Disease life cycle of Crown Rust

Spring	Summer	Fall	Winter
If alternate host (Common buckthorn) is not present spores are brought into Canada on wind current from the United States. If alternate host is present spores are released than can be carried to host crop plants.	Symptoms appear on infected plants and disease spreads. Spores are continuously produced in the summer resulting in secondary infection.	When alternate host is present the fungus produces spores that infect buckthorn.	The fungus overwinters on common buckthorn . On buckthorn the fungus is able to produce thick walled spores that can survive harsh winter conditions. If buckthorn is not present only asexual spores are produced that cannot overwinter in Canada

(Bailey et al. 2003; McCallum et al., 2007)

Symptoms

Identified by the presence of orange pustules that occur on both the upper and lower leaf surfaces, turning black as they mature. In severe infections glumes and sheaths can also be infected. Pustules contain spores that spreads to neighbours and produce a new pustule in 7-10 days in ideal conditions (Saskatchewan Ministry of Agriculture, 2009).



Management

- Resistant cultivars are the most important management tool. (See varieties).
- Early planting allows crop to reach maturity before infection becomes severe.
- Buckthorn should be removed to prevent sexual reproduction resulting in new strains and prevent the fungus from over wintering.
- Scouting should take place July through August (Chong, J et al. 2009).
- Foliar fungicides can be used to achieve control in infected crops. (Bailey et al, 2003)
  - The ideal time for fungicide application is flag leaf emergence.
  - Application should be based on weather and the movement of spores from the south. (Saskatchewan Ministry of Agriculture, 2009).

Stem Rust

Is a fungal disease of cereals, problematic in Manitoba and Eastern Saskatchewan but can occasionally be found in Alberta. On susceptible varieties, this disease can result in devastating yield and quality losses. New races can be brought in to Canada via wind currents and storm fronts. These new races can cause disease on previously resistant oat cultivars (McCallum et al., 2007).

Like crown rust, stem rust is favoured by humid, windy weather with temperatures ranging from 10 - 20°C (MAFRI, Unknown a).

Table 13. Disease cycle of Stem Rust

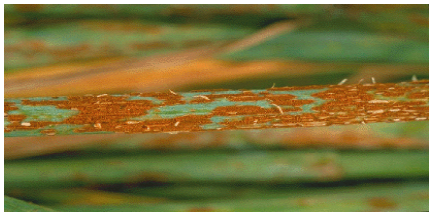
Spring	Summer	Fall	Winter
If alternate host (Common barberry) is not present spores are brought into Canada on wind current from southern United States and Mexico where the fungus can over winter. If alternate host is present spores are released than can be carried to host crop plants	Symptoms appear on infected plants and disease spreads. Brick red pustules appear on the stems of susceptible cultivars about 7-14 days after spores land on infected plants. Pustules are capable of producing about 10,00 spores per day per pustule.	When alternate host is present the fungus produces spores that infect barberry.	The fungus overwinters on common barberry when present. On this alternate host the fungus forms thick walled spores that can survive harsh conditions. If common barberry is not present only asexual spores are produced that cannot overwinter in Canada

(Bailey et al., 2003)

Symptoms:

Infected oats have brick red pustules on the infected stems, turning black with crop maturity. Pustules may be seen on the leaves, glumes and awns (MAFRI, Unknown b).

Stem rust can be often confused with crown rust. One distinguishing factor is crown rust develops orange pustules on the upper and lower leaf surfaces not the stem.



Management

- The most important management tool is the use of resistant varieties.
- Where the alternative host, common barberry, is present it should be removed
- Early seeding of oats is typically effective. This is because the crops exit the susceptible stage before spores arrive for the United States.
- Scouting should be done July-August (Fetch et al. 2009)
- Fungicides are available for control of this disease. Decision about whether or not to apply fungicides should be based on how much disease is present and whether or not application is economical (Bailey et al. 2003).

Yellow Dwarf (Red Leaf)

Is a viral disease caused by the Barley Yellow Dwarf Virus (BYVD) vectored by aphids. Oats are the most sensitive to this disease of the major cereals (Bailey et al, 2003). Yield losses are typically not of economic importance as infected aphids usually arrive late in the season. Early seeded cereals escape the infection period (AAFRD, 2008 a).

Five common aphids can vector this virus, the most common vector is the birdcherry-oat aphid (MAFRI, Unknown c) (See insects).

Outbreaks of this disease are sporadic because the disease is reliant on aphids carrying the virus being present in the oat crop (Bailey et al., 2003).

The symptoms of this disease are most severe when there is a cool period that is followed by a heat shock (period of high temperatures) (Bailey et al., 2003).

Table 14. Disease Cycle of Yellow Dwarf Disease

Spring	Summer	Fall	Winter
Virus is vectored by aphids that move into Canada from the United Stated on wind currents	Oat plants are infected through feeding aphids carrying the virus	As temperatures drop aphid populations die out	As the vectoring aphids cannot over winter in Canada neither does the virus

(Bailey et al., 2003)

Symptoms

Symptoms will vary with environmental conditions. The disease will first appear in localized patches within a field. Plants will display red, yellow or purple discoloration on infected leaves. Other symptoms include; stunting, blasting, and thicker, less flexible leaves. The symptoms of this disease can be commonly confused with those associated with some nutrient deficiencies (Bailey et al., 2003) (See plant nutrient interactions)

Management

- The most effective management tool is to grow resistant cultivars (AAFRD, 2008 a)
- Early seeding will reduce damage. Oats will be more tolerant of infection by the time aphids enter into Canada (Bailey et al., 2003)
- Scouting for this disease should take place from July through August (Gill, 1970)

Smuts, Loose and Covered (Bunt)

Covered and loose smut are fungal diseases that occur everywhere oats are grown. Loose smut is favoured by cool, wet weather in July. The infection prolongs flowering period which increases the susceptible period. Covered smut is favoured by drier conditions (AAFRD, 2010 a; Bailey et al., 2003).

Table 15. Disease cycle of Smut

Spring	Summer	Fall	Winter
The spores on the infected seed germinate and invade the growing point of the young seedlings. The fungus grows with the crop plant until flowering.	Upon flowering the fungus destroy the flowers and replaces most of the seeds and glumes with fungal spores.	The spores are dispersed by wind to infect healthy florets where they stay dormant on the seed until the next spring. For covered smut spores are most often dispersed during harvest and handling of seeds.	Fungus over winters as seed born spores on or under the hull of infected seeds.

(Bailey et al., 2003)

Symptoms

Infected plants are stunted with symptoms mainly on the panicle and exhibit a narrower and more erect growth habit.

Loose Smut

- Seeds, hulls, and glumes are replaced with a powdery mass of dark brown spores
- Most of the spores are blown or washed away with only few fragments of the panicle.

Covered Smut (bunts)

- Compacted spores are enclosed in the remaining hulls and glumes that turn light grey after maturity. (Bailey et al., 2003)
- Infected seeds smell like dead fish or a burning belt.

Management

- The most important management strategy is to plant resistant cultivars.
- If a susceptible cultivar is planted clean seed and fungicide seed treatment is recommended. (Bailey et al, 2003)
- Scouting should occur in July during anthesis and seed development (Menzies et al. 2009).

Stagnospora (Septoria) Leaf Blotch

Septoria leaf blotch is more common in Eastern Canada, but can be found in Western Canada as well. The pathogen overwinters on crop stubble and in the spring will infect the crop in the next growing season. (Bailey, 2003)

This disease is favoured by wet windy weather and mild temperatures (15-25°C), persisting for more than 6 hours. (MAFRI, Unknown a)

Table 16. Disease cycle of Stagnospora (Septoria) Leaf Blotch

Spring	Summer	Fall	Winter
Spores are produced on crop stubble.	Oat crop is infected at the boot stage. More spores are produced that spread to adjacent healthy plants.	With severe infection stems become black and the risk of lodging increases.	Over-winters on crop residue.

(Bailey et al., 2003)

Symptoms

Leaf lesions first appear as small round or elliptical purplish brown spots that can be up to 1 cm in length, covering most of the leaf surface.

Lesions on the stem will be greyish brown to slightly black and dark brown blotches can be present on the panicle, glumes and seed. (Bailey, 2003)

Management

- The most effective control tool is resistant varieties.
- Sanitation of machinery will prevent the introduction of disease.
- Seeding early will allow avoidance of the highly sensitive stage.
- Crop rotation of a minimum of two years between oat crops.
- Scouting should be done from July-August (Tekauz et al., 2009 b)
- Foliar fungicide application can minimize yield losses when economically viable. (Bailey, 2003).

Summary of Diseases

Table 17. Summary table of diseases of oats

Disease	Areas of Highest concern	Favourable conditions	When to scout	Control options
Fusarium Head Blight	Highest concern in Manitoba and Saskatchewan with little importance in Alberta. Common in the black soil zone where rain fall is high.	Humid summers	July-August	• Tillage • Crop rotation or 2 to 3 years between susceptible crops • Control alternate hosts • Plant certified disease free seed • Apply fungicides when economically viable
Crown Rust (Leaf Rust)	Highest economic concern in Southern Manitoba and south eastern Saskatchewan and occasionally important in Alberta.	Humid and windy conditions with temperatures between 10-20°C)	July - August	• Select resistant varieties • Seed early • Remove common Buckthorn when present • Apply fungicides when economically viable
Stem rust	Highest economic concern in Southern Manitoba and south eastern Saskatchewan and occasionally important in Alberta.	Humid and windy conditions with temperatures between (10-20°C)	July - August	• Select resistant varieties • Seed early • Remove common barberry when present • Fungicides when economically viable

Yellow Dwarf (Red Leaf)	Sporadic occurrence in Manitoba, Saskatchewan and Alberta.	Symptoms are most severe when there is a cool period that is followed by a period of high temperatures.	July - August	• Select resistant varieties • Seed early
Smuts (Covered and loose)	Occurs everywhere oats are grown.	Loose smut favoured by cool wet weather in July Covered smut favoured by dry conditions	July	• Select resistant varieties • If susceptible cultivar is planted use disease free seed
Stagnospora (Septoria) Leaf Blotch	Most common in Eastern Canada but can occur throughout Western Canada.	Continuous moist, windy weather for at least 6 hours with mild temperatures (15 -25°C)	July-August	• Select resistant varieties • Sanitation of machinery • Seed early

Disease Comparison for Oats and Barley

Table 18. Disease comparison for oats and barley.

Disease	Oats	Barley
Fusarium Head Blight	• Highest economic concern in Manitoba and Saskatchewan. • Minimal yield losses with few in field symptoms. • Mycotoxins on seed reduces marketability.	• Highest concern in Manitoba and Saskatchewan. • Higher yield losses than in oats but similar to losses in wheat. • Presence of mycotoxins on seed reduces marketability.
Crown Rust/Leaf Rust	• Highest economic concern in Manitoba and Saskatchewan and can occasionally occur in Alberta. • Yield losses can be up to 100% if severe infection occurs. • Requires alternate host (common buckthorn) to overwinter. • Spores usually arrive in Canada on wind currents from Southern United States.	• Not of economic concern on barley in Western Canada.

Stem Rust	• Highest economic concern in Manitoba and Saskatchewan and can occasionally be found in Alberta. • Requires common barberry to overwinter. • Spores usually arrive in Canada on wind currents from Southern United States.	• Highest concern in Manitoba and Saskatchewan but can be also found in Alberta • Requires common barberry to overwinter. • Spores usually arrive in Canada on wind currents from Southern United States. • There is less disease pressure due to increased resistant winter wheat varieties being planted in the United States. • A different strain affects oats than barley and wheat.
Yellow Dwarf (Red Leaf)	• This disease is dependent of the arrival of infectious aphids on wind currents from Southern United States. • Oats are highly sensitive. • Tolerant varieties do exist but are not completely resistant.	• This disease is dependent of the arrival of infectious aphids on wind currents from Southern United States. • Less sensitive that oats. • Tolerant varieties do exist but are not completely resistant.
Smuts	• Smuts are common throughout Canada. • Economic importance is reduced with the availability of resistant varieties and fungicidal seed treatments. Most available oat varieties are resistant to smuts. • Oats are infected by common smut (bunt) and loose smut.	• Smuts are common throughout Canada. • Economic importance is reduced with the availability of resistant varieties and fungicidal seed treatments. • Barley can be infected by covered smut, loose smut and false loose smut.
Common Root Rot	• Widely distributed in Canada. • Symptoms on oats are often inconspicuous. • Not of economic concern.	• Barley in Western Canada common root rot can cause annual losses of around 10%. • This disease is widespread throughout Canada.
Leaf Stripe	• Not of concern in oats.	• Found in parts of Western Canada especially in the Peace River Region. • Uncommon and occurs at low levels but if not managed can cause significant crop losses. • Most barley cultivars are susceptible.
Net Blotch	• Not of concern in oats.	• The most common foliar disease of barley and occurs throughout most of the prairies. • Yield losses can be as high as 40%. • Levels of seed infection have been found to be as high as 80%.

Scald	• Not of concern in oats.	• Highest concern in the north-western areas of the prairie provinces. • This disease is favoured by cool, wet conditions • There will be reduced grain filling and smaller kernels.

(Bailey et al. 2003)

Natural Enemies

Natural enemies can be very successful in controlling pest populations. Such enemies can be predators, parasites or pathogens.

Predators consume pests at different stages of development. Examples of predators include lady beetle and blister beetles.

-Asian lady beetle eating aphids

Parasites lay their eggs on or in the pest. The developing parasitic larva consumes the tissue of the host insect and kills it. There are many parasitic wasps and flies that parasitize major crop pests.

Pathogens can be viruses, fungi, bacteria or protozoa. These disease causing agents cause various levels of harm and are often dependent on environmental conditions (AAFRD, 1986).

Managing cropping systems to promote natural enemy populations includes;

- Reducing insecticide application
- Select insecticides with minimal impact on natural enemies
- Timing application for maximum control of pests with minimum impact on natural enemies (AAFRD, 1986).

-A wasp parasitizing an aphid

Insects

Cereal Leaf beetle

A pest of cereals. The cereal leaf beetle was found in Southern Alberta in 2005, and has now been seen in Saskatchewan and Manitoba (Canadian Food Inspection Agency, 2006).

Oat fields infested with cereal leaf beetle and not treated with insecticide have been known to suffer yield losses up to 75% (Dosdall, L., personal communication).

Table 19. Insect biology of cereal leaf beetle

Spring	Summer	Fall	Winter
When temperatures reach 20°C the adults become active and begin feeding on wild grasses After approximately 14 days they move into crops and begin laying eggs The eggs are layed on the upper surface of grass leaves and about halfway up the plant Each female adult can lay 100-400 eggs over a 50 day period	Eggs hatch after about 5 days and the larvae feed for about 8-12 days. After the feeding period is up the larvae pupate in the soil at depths of up to 2.5 cm	This insect pupates for two to three weeks. After this period the new adults emerge from the soil. The complete life cycle is complete in 46 days When temperatures drop adults search for over wintering sites	Adults are the over wintering stage They over winter in cluster in crevices of tree bark, under field trash, inside rolled leaves or in bee hives

(Canadian Food Inspection Agency, 2006)

Symptoms

- Both adults and larvae damage the plants through feeding. Long strips of tissue between the veins of the leaf will be removed.
- With extensive feeding damage the leaves can turn white and resemble frost damage.
- Yield reduction and premature death can occur (CFIA, 2006).

Identification:

Adult

- Bluish black wing covers, head, antennae and abdomen
- Thorax and legs are slightly orange-brown with dark spots on the legs
- Females (4.9-5.5 mm) are larger than males (4.4-5 mm) (CFIA, 2006).

Egg

- Yellow, cylindrical eggs between 0.4 - 0.9 mm in length, turn black just before hatching (CFIA, 2006).

Larvae

- The larvae are slug like and slightly longer than the adult.
- The larva, which is yellow, usually cover themselves with fecal matter for camouflage (CFIA, 2006).

Scouting techniques:

- Scout weekly, right after plant emergence.
- Adults are not recommended to be treated but their abundance will be predictive of larval presence.

Walk the crop in a W shape and stop at 5-10 locations at look at 10 plants at each location. Record the number of larvae and eggs per plant for small plants or per stem for larger plants. Consult economic threshold table. (Government of British Columbia, 2010; Hodgson and Evans, 2007)

Table 20. Economic thresholds for cereal leaf beetle in oats

	Before boot stage	After boot stage
Economic threshold	3 eggs or larvae/stem	1 larvae/ flag leaf

(Government of British Columbia, 2010; Hodgson and Evans, 2007)

Natural enemies

- There are two main known parasitic wasps; affecting larvae and eggs (Dosdall, L., personal communication).

Management:

- Promote full crop stands as cereal leaf beetles prefer to colonize weak stands.
- Plant early as beetle prefer young plants
- Heavy rain or irrigation can kill larvae. As a result, if a heavy rain has occurred after scouting it is recommended to scout again
- To prevent yield loss insecticides may be applied (Hodgson and Evans, 2007).

Aphids

- The major aphids found in Western Canada are, the English grain aphid, the bird cherry-oat aphid, the Russian wheat aphid and the green bug. Damage is often not economically significant as these aphids cannot overwinter in Canada. Infestations do occur periodically when sufficient aphid populations are brought into Canada (MAFRI, 2010 a).

Table 21. Insect biology of aphids.

Spring	Summer	Fall	Winter
Aphids are brought into Canada by wind currents coming in from the United States.	Aphids feed on plants and populations increase. Feeding damage symptoms may be seen in localized patches.	As temperatures drop aphid populations may die off.	Aphids cannot over-winter in Canada.

(MAFRI, 2010)

Identification

Bird cherry oat aphid

- Mostly found on lower leaves and stems.
- The vector of the barley yellow dwarf virus (see yellow dwarf disese)

-Bird cherry oat aphid

English grain aphid

- Mostly found on the head and upper leaves of the plant.

-English grain aphid

Greenbug

- Saliva of this insect is toxic to plants.
- When feeding the toxic saliva results in discoloration and brown spotting on leaves. (MAFRI, 2010 a)

-Greenbug

Russian Wheat Aphid

- Saliva of this insect contains a toxin that reduces that chlorophyll in the plant, this can result in leaf curling (Karren, 1989).

- Russian wheat aphid

Economic Thresholds

Table 22. Economic thresholds of aphids

	Seedling stage	Boot stage	Dough stage to crop maturity
English Grain Aphid	30 insects/stem	50 insects/stem	Do not treat
Birdcherry Oat Aphid	20 insects/stem	30 insects/stem	Do not treat
Greenbug	5-15 insects/stem	10-25 insects/stem	Do not treat
Russian Wheat Aphid	10-15% of scouted plants are infested	15-20% of scouted plants are infested	Do not treat

(AAFRD, 2008 d)

Symptoms

- Leaf discoloration and brown spotting
- Patches of sever infestation may appear as large bronzy or brown patches within a field. These patches may have a reduced plant stand later in the season. (MAFRI, 2010a).

Scouting techniques

- Monitor July through early August
- Check 20 stems in 5 different areas at least 50 paces apart and near the center of the field. Record the total number of aphids and take an average per plant. (MAFRI, 2010a).

Natural Enemies

- Predators:
  - Lady beetles (Lady bugs)
  - Lace wings
  - Big-eyed bugs
- Parasites:
  - Parasitic wasps
- Pathogens:
  - Various fungal pathogens

Populations of these insects should also be considered when choosing insecticide treatment (AAFRD, 2008 a).

Management options

- Early seeded crops will be passed the susceptible stage before aphid populations reach damaging levels.
- When aphid populations are above economic thresholds insecticides may be used (MARFI, Unknown a).

Wireworms

Larvae feed on germinating seeds and young seedlings. Damaged plants result in thin stands and often die. The preferred hosts are grasses but wireworms can also attack corn, carrots, potatoes, wheat, barley, sugar beets, lettuce and onions (MAFRI, Unknown b).

Insect Biology

Table 23. Wireworm biology

Spring	Summer	Fall	Winter
Adults emerge from the soil in the spring Between May and June and adult females may lay 200-1400 eggs in loose or cracked soil or under soil lumps.	The larvae hatch and feed on roots or developing seeds	Larvae continue feeding	Over winter as adults or larvae Larval stage can last for 1-5 years

(MAFRI , Unknown b)

Symptoms

- Thin stands
- Wilted and discoloured plants remain attached to the root.
- The feeding by the larvae shred the stem of young seedlings causing the central leaves to die.
- Damage can be confused with cutworm damage. With wireworm damage the plants remain attached at the roots (MAFRI , Unknown b).

Identification

- Larvae are slender, segmented and hard bodied.
- They have three pairs of legs behind the head.
- The last abdominal segment is flattened with a keyhole shaped notch.
- Full grown larvae will be 1-4 cm in length (MARFI, Unknown b).

Scouting Techniques

- Soil samples are used to estimate the presence of wireworms
- Sample areas should be 50 cm x 50 cm and the soil should be sieved to a depth of 15 cm
- Repeat in different areas in the field. (MARFI , Unknown b)

Management Options

- Sampling should occur by sifting the soil to look for larvae from early to mid August (AAFRD, 2006 b).

- The action threshold is 32 wireworms per square meter, beyond this level seed treatment is recommended the following year.
- When sod is broken, seed treatment is recommended for two consecutive years (MARFI, Unknown b).
- There is no treatment available once the crop has been seeded.

Cutworms

The most damaging cutworm species are the red-backed cutworm, dingy cutworm, glassy cutworm, dark sided cutworm, pale western cutworm and the army cutworm (Paeir, 2008). The red-backed cutworm is of highest significance in Manitoba, while the army cutworm causes the most damage in Alberta and Saskatchewan (MAFRI, 2009 c).

Insect Biology

Table 24. Cutworm biology

Spring	Summer	Fall	Winter
Over wintering eggs hatch and over-wintering larvae begin feeding	After 6 larval stages the larvae will pupate and adult moths will emerge	For some species egg laying occurs in the fall	Some cutworm species over winter in as eggs
Larvae are nocturnal feeding at night and hiding during the day			Some cutworm species over winter as larvae

(MARFI, 2009c)

Symptoms

- Notched, wilted, dead and cut off plants.
- Plants may be missing from rows and there may be bare patches within a field (MAFRI, 2009c).

Identification

- Red-backed Cutworm

- Army Cutworm

- Dingy Cutworm

Scouting techniques

- Scouting should occur from mid-May to mid-June.
- Identify areas suffering from possible feeding damage, cutworms will be near the base of the severed plants.
- Cutworm larvae can be collected from the soil using a shovel and a sift, with samples taken from at least 5 cm depths.
- The cutworm larvae will curl up and attempt to hide in debris.
- When counting the larvae it is important to note the size of the larvae.
- Small larvae are of most concern as they eat a lot to reach full size and therefore have a greater damage potential (MAFRI, 2009c).

Management Options

- For red-backed and army cutworms the economic threshold is 5-6 larvae/m².
- At and above the threshold levels insecticide treatment is recommended if economically viable.
- Application should occur in the evening and if applicable only applied to infested patches.
- There is no economic threshold for dingy cutworms
- There are many parasites and fungal diseases of cutworms.
- Soils with good moisture can tolerate higher numbers of larvae.
- Reduced till systems tend to have less outbreaks than conventional till systems. Due to increase parasite diversity in these systems (MAFRI, 2009c).

Cutworms Wireworm

Insect Summary Chart

Table 24. Insect summary chart

Insect	Where they occur	When to scout	Management options
Cereal leaf beetle	Recently found in Western Canada.	Weekly from crop emergence until after boot stage	• Promote full, healthy crop stands • Seed early • Heavy rain or irrigation can kill larvae. • Insecticides can be applied to prevent yield losses when populations exceed economic thresholds. • Before boot stage 3 eggs or larvae/ stem • After boot stage 1 larvae/flag leaf
Aphids	Are found in Western Canada.	July - August	• Seed early • Insecticides may be applied if populations are above economic thresholds .
Wireworms	Are found in Western Canada.	Early to mid August	• Apply seed treatment in the following year when populations are above 32 wireworms/ square meter. • When sod is broken seeds should be treated for 2 years.
Cutworms	Are found in Western Canada	Mid May -July	• Insecticides can be applied when populations exceed economic threshold • Adopt reduced till systems • Consider natural enemy populations when choosing insecticide.

Insect comparison for Oats and Barley

Table 25. Insect comparison for oats and barley

Insect	Oats	Barley
Cereal Leaf Beetle	• Feeding damage can cause yield losses of up to 75%. • Has recently been found in Alberta, Saskatchewan and Manitoba.	• Barley is a host of this insect. • There is a potential of high yield losses.
Aphids	• Arrive in Canada on wind currents from the United States. • Feeding damage and toxic saliva can reduce yield. • Aphids can vector the Barley Yellow Dwarf Virus.	• Barley is a host plant to many of the aphids that are problematic to oats. • Aphids can vector the Barley Yellow Dwarf Virus.
Wireworms	• Feed on seeds and seedlings resulting in thin stands. • There is no treatment options for the current cropping year. • Seed treatments can be used in subsequent years.	• A preferred host of wireworms. • Damage levels and control options are the same as oats.
Cutworms	• There are six dominant species of cutworms. • With severe infestations plants can be cut off leaving bare patches in the field.	• Cutworms are a major pest of barley. • The same species that are problematic on oats also cause problems on barley
Grasshoppers	• Typically not a problem in oats	• When grasshopper populations are in high, yield losses can be extreme. • Damage often includes leaf notching, stripping or severing of stems just below the heads of maturing crops • Grasshopper populations are favoured in dry conditions

(CFIA, 2006; MAFRI, Unknown a; MAFRI, Unknown b; MAFRI, 2009c; AAFRD, 2006)

Seeding Management

Seeding Date

Seed Early

- This will maximize yield by increasing seed size, number, and test weight.
- Early seeded oats will be better able to utilize spring moisture.
- Oats will have greater tolerance to spring temperatures and frost than canola (OMAFRA, 2009).
- Seeding in early May vs. mid-June can increase oat yield by up to 76% (May, 2004).
- Seed to avoid crop flowering during the hottest parts of the season leading to heat blast (MAFRI, 2010).
- Early seeding can reduce the window of susceptibility to diseases like crown rust and Barley Yellow Dwarf Virus (May, 2004).
- Oat crops that emerge relatively earlier than wild oats will have a competitive advantage (Willenborg, 2005) (See weed control)
- Later seeded oats will have fewer days to maturity but will experience a yield decrease (May, 2004).

Soil Temperature

- Minimum germination temperature is 5^{o}C.
- Seeding into cooler temperatures will result in slower germination and increased exposure to soil diseases and insect predation.

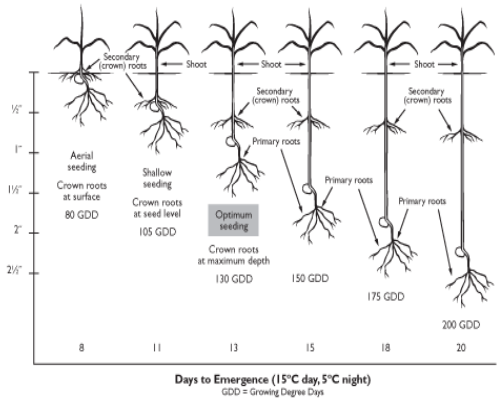
Seeding Depth:

- Recommended depth for cereals is 1.5 – 2.5 inches, or to available moisture (MAFRI, unknown)
- Shallow seeding can promote early emergence and give the crop a competitive advantage over weed seedlings (O'Donovan, 2007).
- If moisture conditions are good, oats can be seeded as shallow as 1 inch to promote rapid emergence. (AgCan, unknown)
- Later seeded oats can be placed up to 3 inches deep to find moisture (MAFRI, unknown).

Oat Development:

Germination requires 80 growing degree days (OMAFRA, 2009).

- Add on another 50 growing degree-days to germinate for every inch of seeding depth. (OMAFRA, 2009).
- Growing degree day for cereal *=((max daily temp+min daily temp)/2) – 0* (OMAFRA, 2009).



Seeding Rate:

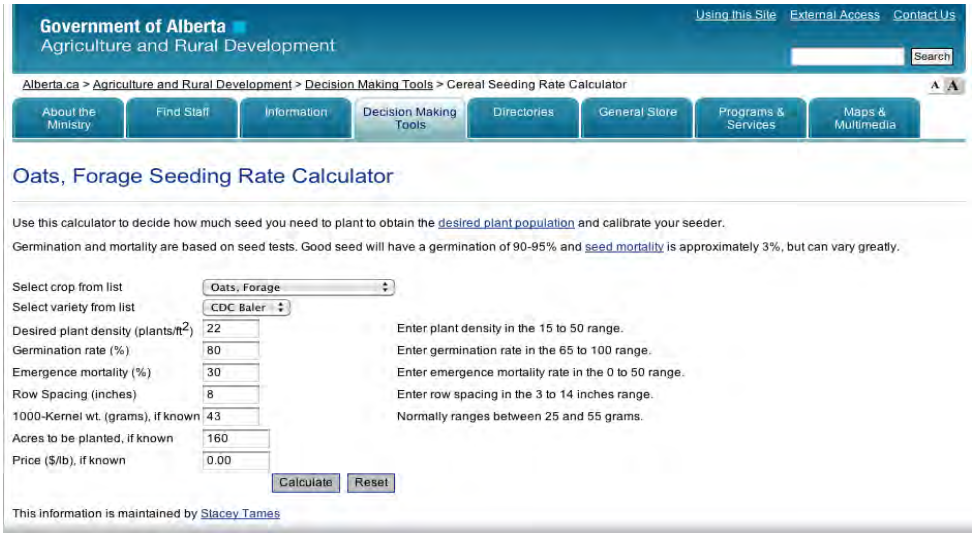
- Aim for a plant population of 200-250 plants per m^2 or 18- 24 per sq ft, approximately 1.5 – 3bu/ac (O'Donovan 2007).
- Varying oat sizes and hull weight must be taken into consideration, it is better to determine thousand kernel weight. (MAFRI, unknown).
- Seeding at a higher density will improve weed management and crop yield (O'Donovan, 2007).
- Account for a 70-80% seedling survival rate, hulless oats will have a significantly lower seedling survival rate (May, 2004; MAFRI, unknown).
- Seeding rates should be increased if broadcasting, planting late, or seeding into poor soils (i.e old hay land or heavy clay) (OMAFRA, 2009)
- Seed testing for germination and vigor is recommended

To Calculate Seeding Rate:

Seeding rate calculators can be found at Alberta Agriculture Website:
Cereal Seed Calculator:

lbs/ac = Desired plant population/ft^2 x TKW (g.)/ Seedling survival rate/ 10.4

kg/ha = Desired plant population/ m^2 x TKW (g.) / Seedling survival rate/100



Intercropping

Intercropping is the practice of growing two different crops on one piece of land simultaneously.

Oats can be intercropped with alfalfa, peas, clover and other forage and pulse crops.

Intercropping is becoming more popular in the Prairie Provinces, and can be used with organic production. (Chalmers and Day, 2009).

Benefits of Intercropping:

- Increase the yield and quality of your crops because all of the nutrients, water and light are utilized every year.
- Decrease the amount of weeds present by increasing crop competition.
- With a pea/oat crop it can expand the optimum time to silage by as much as 12 days.
- Increase total economic value per acre.
- A main benefit of intercropping is in silage, where you can get an increased overall silage mass, as well as a greater amount of required nutrients for feed (Chalmers and Day, 2009).

Calculating the benefits of Intercropping:

To find the benefits of intercropping the Land Equivalent Ration (LER) will measure the comparative value of intercropping versus a single crop. If the LER is greater than 1 you will have a more productive stand in intercropping.

$$LER = \frac{\text{Yield of Crop A in Intercropping}}{\text{Yield of Crop A Pure Line}} + \frac{\text{Yield of Crop B in Intercropping}}{\text{Yield of Crop B Pure Line}}$$

When mixing peas/oats in Manitoba the LER is 1.2. This means that it would take 20% more land to have the same yield if the crops were grown as two separate crops (Chalmers and Day, 2009).

Harvest

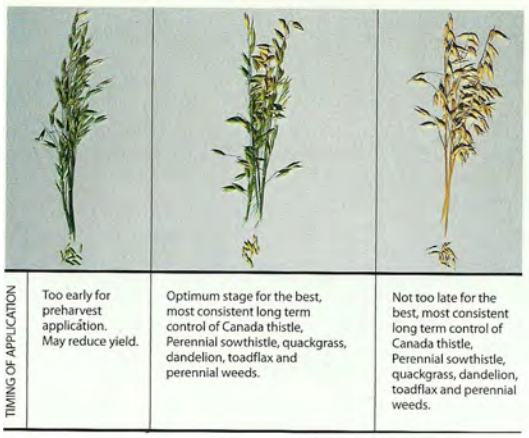
Swathing

Oats are typically swathed and then combined (May et al. 2005). Swathing of oats should start when the kernel moisture content is about 35% (POGA, Unknown). This ensures that shattering losses are kept to a minimum (May et al. 2005). At moisture levels above 35% yield, groat yield and test weight can be negatively affected. The stand is ready to be swathed when the majority of panicles have turned yellow or brown. Green stems are not an indication of immaturity (POGA, Unknown).

Pre-harvest Glyphosate

An application of glyphosate before harvest will not only provide perennial weed control, but also allows seed heads to mature uniformly. Uniform maturity reduces shatter loss (Monsanto, Unknown). Whether swathing or straight cutting, an application should be applied prior to the crop reaching 30% moisture (POGA, Unknown). At this moisture level, the seeds will have reached the hard dough stage (See staging guide).

If the crop is desiccated with glyphosate before harvest, you should contact the end users to ensure this is an acceptable practice. A pre-harvest application can result in poor seedling vigor and reduced emergence (Saskatchewan Ministry of Agriculture, 2008a). Be sure to check labels before applying (POGA, Unknown).



Combining

Once desired moisture is reached, swathed oats may be threshed. Oats left in the swath too long can decrease in quality due to weathering. To straight combine oats, ensure all oats have ripened; green seeds will be discounted. Less ripe areas can be avoided on the first pass and cut at a later date.

If mature oats are left standing too long, weather may cause the stems to break down. The panicle becomes highly susceptible to shattering with heavy rain, wind or hail (POGA, Unknown).

At lower moisture levels there is greater loss during harvest. However, at higher moisture levels it must be kept in mind that there may be an increase in green seed (Clarke, 1984). There is less loss due to shattering in swathing compared to straight cutting.

Table 26. Effect of harvesting oats at three kernel moisture ranges on harvesting losses of oats for windrower

Loss Component	Cut at	Cut at	Cut at

	31-39%	16-21%	9-15%
	Average of 2 years of data (g/m^{-2})		
Shattering	0.76	1.04	2.27
Cutting	0.68	1.06	1.23
Pick-up	1.33	1.08	1.81
Total Windrower/Combine	2.77	3.18	4.31
Direct Combine	1.44	2.1	3.5

(Clarke, 1984)

De-hulled oats can result in a sample being down-graded. Hulless oats are highly vulnerable to cracking and damage. Combine cylinder, rotor speed and concave clearances should be adjusted properly to avoid this damage (POGA, Unknown).

Storage

The moisture content of oats should be 12%. It harvested at the 14% moisture content, oats must be taken to market within 30 days to prevent heating, moulding or spoilage. (AAFRD, Unknown)

If the crop cannot be taken to market within 30 days, the moisture content can be decreased through aeration or artificial drying. Cooling is just as important as drying your grain.

"*An air flow of 1-2 L/s-m3 (0.08 - 0.16 cfm/bu) is recommended for adequate drying and cooling*" (AAFRD, Unknown).

Care must be taken to prevent over-heating of the oats. The suggested temperature for drying oats as reported by Alberta Agriculture:

- for seed use: 50 °C
- for milling use: 60 ° C
- for feed use: 80-100 ° C

Overheating of the grain, especially when the oats are dehulled, may lead to rancidity. This is reason for concern as heating causes degradation of some lipids and other components and produce toxins (mycotoxins) harmful to human health (Molteberg et al. 1996). To deter this, temperature and moisture should be monitored throughout storage.

If the seed was green, frost damaged, mechanically damaged or had high moisture content at harvest, a germination test should be conducted in the spring. This ensures that quality has not decreased in the bin over winter (Saskatchewan Ministry of Agriculture, 2008 a.).

Pests in Stored Grain

Insects

Insects that most commonly feed on grain are the rusty grain beetle, red flour beetle, and the saw-toothed grain beetle.

Correct identification is important when determining control methods as some insects found in stored grains feed on the grain, while others feed on fungus develop in stored grain. Some examples of fungus feeders are; foreign grain beetles, grain mites and psocids. There is a zero tolerance policy for any grain feeder insects. There are many prevention and control methods. (Saskatchewan Ministry of Agriculture, 2008 b).

Preventative measures:

- *Clean storage facilities* – Storage and transport facilities should be thoroughly cleaned before use. If needed, the facilities are sprayed and/or dusted with a recommended insecticide.
- *Dry and cool grain* – ideally grain should be dried, cooled and stored as quickly possible after harvest. Temperature in the bin should be below 15ºC as this discourages insects from laying eggs and developing.
- *Monitoring for insects* - shows the first indication of a problem. Probe traps are available and should be placed at the top centre of the storage bin. Traps should be checked every 7-10 days for the first 60 days and then adjusted accordingly.

Control measures:

- *Cold temperatures* – stored grain insects can be killed by reducing core grain temperatures as follows:

Table 27. Time Required to Kill Insects at Various Grain Temperatures

Grain Temperature	Time required to kill insects
-5°C	12 weeks
-10°C	8 weeks
-15°C	4 weeks
-20°C	1 week

(Saskatchewan Ministry of Agriculture. 2008b)

- *Moving Grain with Pneumatic Conveyors (grain vacs)* – has known to be an effective method of control
- *Insecticides* – such as Phostoxin™, Protect-It™, Insecto™, Tempo 20 WP™.

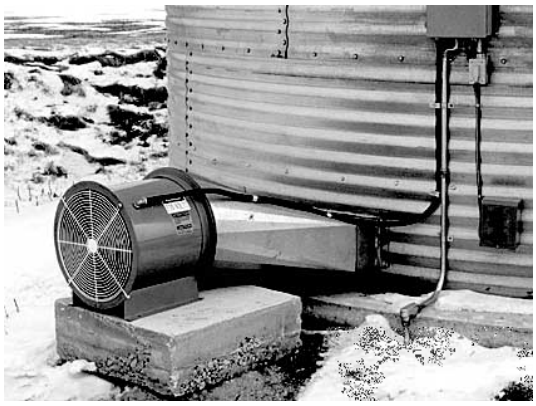
Fungus

Fungus commonly enters stored grain through foreign material such as spores on seeds, or farm machinery. Fungus develops in conditions of high seed moisture, high temperatures, or accidental wetting of the grain (Saskatchewan Ministry of Agriculture, 2008 b).

Fungal growth diminishes seed quality due to; heating and spoiling, packing or caking effects, poor germination and production of off-odours. Fungal infection may produce toxins, which are harmful to livestock. These toxins (mycotoxins) are only detectable through lengthy and complex chemical analysis (Saskatchewan Ministry of Agriculture 2008b).

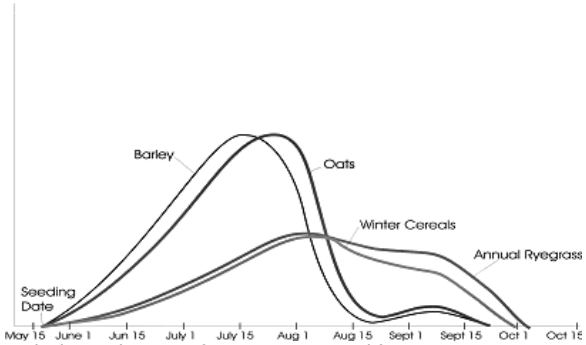
Preventative measures:

- *Well designed and constructed granaries* – prevent mould infestations and preserve grain quality
- *Storing smaller quantities of grain*- cools and dries seeds quicker, while larger bins can have condensation at the surface or sides promoting fungal growth.
- *Cooling grain to -8ºC* – inactivates mould growth
- *Aeration* – helps to reduce grain temperature. Fans should be started as soon as the grain is placed in the bin.
-



Oats for Forage

Oats can be used in the prairies for greenfeed, silage and pasture (Saskatchewan Ministry of Agriculture 2008c). Oats provide emergency or supplementary forage as well as a short-term land commitment. Forage oats are easy to seed, establish quickly and can provide pasture later in the growing season. Much of the forage is produced eight to ten weeks after seeding. When using as pasture, late season use can lead to considerable wastage from trampling and maturity. However, if this occurs oats can be harvested for greenfeed, grain or swath grazed (Saskatchewan Ministry of Agriculture, 2008c). (See forage oat varieties)



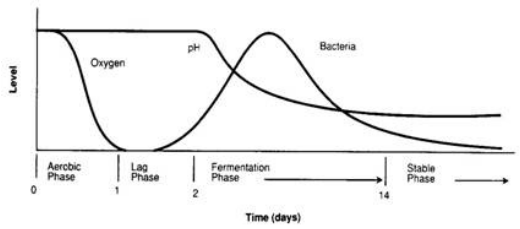
Typical growth curves for common annual forage crops grown in Saskatchewan (from Sask Ag)

Green feed, Silage, Haylage and Hay

Oats should be harvested for greenfeed, silage, haylage and hay at the late milk stage (See staging guide) (Saskatchewan Ministry of Agriculture, 2008c). When used for forage, oats can be cut and conditioned in the same manner as traditional hay. Wilt the crop to 40 - 60% moisture and then bale at the correct moisture.

Baling material used for haylage that is too dry will result in poor fermentation and increased storage losses. Baling too wet reduces the amount of dry matter stored in each bale, which increases costs. Sealing the haylage is key to eliminate oxygen during the wrapping process, preventing spoilage (Saskatchewan Ministry of Agriculture, 2008c).

Silage is the material resulting from the preservation of green forage crops by acidification. The main function of silage is to exclude air during the ensiling process and during storage (Saskatchewan Ministry of Agriculture, 2008d). Some common ways to store silage are in concrete silos, bunkers, heap silage pits and in bales. For more information on silage storage see "Silage storage techniques" on the Saskatchewan Ministry of Agriculture website.



The ensiling process.

Grazing

Staggering spring seeding dates will spread out pasture production (Saskatchewan Ministry of Agriculture., 2008c). Oats can be grazed when they reach 10 inches (25 cm), however there are some risks to grazing an annual crop.

Risks of feeding forage

Generally, annual crops are safe, nutritious and productive for forage. However, environmental factors such as frost, drought, and some plant diseases can negatively affect the quality for livestock feed (Saskatchewan Ministry of Agriculture., 2008c).

Nitrate Poisoning

During digestion nitrates in feed are converted to nitrites. Nitrites reduce oxygen-carrying capacity in the blood causing asphyxiation.

What increases levels of nitrates?

- High levels of soil nitrogen.
- Type of crop.
- Frost or drought that reduces or stops growth (if the plant recovers it will use accumulated nitrates for growth).

Blend high nitrate feed with low nitrate feed to obtain a safe level to reduce the average nitrate content

Keep in mind the nitrate content of the fodder as it may be at dangerously high levels for feeding.

It is in the best interest to have a sample analyzed before use. A nitrate level of 0.5 per cent in feed is potentially dangerous: 0.75 per cent will reduce milk production and 1.5 per cent is usually lethal (AAFRD, 2002).

Atypical Interstitial Pneumonia (AIP)

- Sometimes associated with moving cattle to a lush pasture in late summer/fall.
- If suspected remove the cattle from the pasture, avoid exertion.

Grass Tetany

- Prevalent on lactating cows put on lush spring pasture.
- Prevention:
- proper supplementation of magnesium oxide and limestone.
- adequate energy level in the diet.

Grain Overload

- Occurs when mature cereal crop grazed.

Milk Fever/ Winter Tetany

- Can accumulate excessive levels of potassium.
- Occurs when large percentage of the ration is fed to cows 2-3 weeks prior to calving.
- Feed analysis can determine appropriate nutrient and mineral levels.

Post Harvest

Straw Management:

Overall reduced tillage and direct seeding in combination with high amounts of chopped straw can be adopted on a wide range of soils to increase yield (Borresen, 1999).

Markets and Uses of Oats

Oat Future Markets

Canada accounts for 45-50% of the world's oat exports in 2009-2010, making Canada the world's largest oat exporter. 95% of Canada's oats are exported to the United States, while the rest are exported to Mexico or Japan. (Market Analysis Group: Grains and Oilseeds Division, 2010).

The world production of oats has been declining due to preference for barley and corn as animal feed. The health benefits of oats have helped increase demand for oat products. PepsiCo's Quaker Oats division is developing a method to modify oats that creates a natural sweetener. Oat flour is also being studied as a replacement for individuals who suffer from celiac disease (Market Analysis Group: Grains and Oilseeds Division, 2010).

Classifications of Oats In Western Canada

The market you are interested in selling to determine the type of oat seed you purchased. The following are the types of oat seed available:

- Milling/General Purpose
- Feed Oat
- Hulless oats

The oat market was released by the Canadian Wheat Board in 1989 and currently runs under a free market system. This has given producers a large responsibility in determining their target market (Bouphasiri et al, 2005).

Milling and Performance Markets

Milling Oats are oats that are processed for human consumption. Performance oats refers to those for animal consumption, particularly horses. Both of these markets are heavily reliant on quality. Buyers may have individual quality standards and different levels of acceptance (AAFRD, 2010).

Both types of oats are generally sold on sample basis in the spot market. Samples can be sent to multiple buyers to seek the highest price for your crop. Buyers look for high test-weights, uniform kernel, clean seed, plump kernels, high protein, and low moisture (AAFRD, 2010).

Buyers have preferred varieties that have particular beta-glucans, proteins and oil content levels. There are no premiums for selling oats with these qualities. Here is an example illustrating the difference qualities of performance and milling oat varieties:

Table 28. Preferred variety characteristics

Milling Oat Varieties	Performance Oat Varieties
- High test weight - High Beta-glucan content - Low in oil	- High test weights - High in oil - Only white or golden colored hulls - High in protein

(Mitchell Fetch, J., personal communication)

The hull is removed in the milling process and the groat is kept. Overall quantity increases as groat percentage increases. (AAFRD,2010).

Feed Oats

Feed oats are given the grade of #3CW and #4CW. Although oats are often used as on farm feed, there is still a significant portion exported. Desired oats have

higher test weights and low levels of foreign material. Oats can be sold to neighbors and local feed mills, in a domestic cash market (AAFRD, 2010).

Hulless Oats

There is a niche market for hulless oats, it is advised that producers only grow these under contracts. Hulless oats require extra care in storage in order to prevent rancidity (AAFRD, 2010).

Greenfeed and Straw

The quality is the main determinant of the market which greenfeed and straw is sold. Quality is generally assessed in three values:

- Protein Content
- Feed Value
    - See feed value calculator
- Fiber Content

Other important quality factors are weed content, mould, dust, color, stage of maturity, texture and leafing attachment (Micheal Tembly et al., 2010).

Oat forage can be sold to the:

- Local market
    - Beef market
    - Dairy market
    - Horse market
- Processing market
- Export market

Pricing of Forage Oats

The prices received for silage or greenfeed vary greatly depending on the demand. Transport costs are one of the main factors determining prices. To find out more about the markets in your area consult the following pages: Alberta Hay, Alberta Straw, Saskatchewan and Manitoba.

Pricing of Oats

Milling oat prices are usually based on the Chicago Board of Futures (CBOT) or the Minneapolis cash oat market. Large variations on this price are generally normal. Although companies use this as the base price of oats many factors like cost of storage and shipment affect the price. It's a good idea to verify numbers with your grain dealer if you want to determine the value of your crop (AARFD, 2010).

To determine the oats price use the following information:

- Chicago Board of Futures monthly oat price
- Minneapolis cash oat market
- Exchange rate between US and Canadian Dollars
- The price basis for your particular elevator (AAFRD, 2010).

The Western Producer also supplies the price of oats.

Recently there has been an increase in Manitoba and Saskatchewan milling oats for export to the United States (Bouphasiri et al. 2005).

Alberta production has remained constant, but chooses to sell to the local pony market, millers or for international export (Market Analysis Group: Grains and Oilseeds Division, 2010).

With the removal of the Transportation Act, the price of transportation is reflected in the basis price. The price increases as you move west.

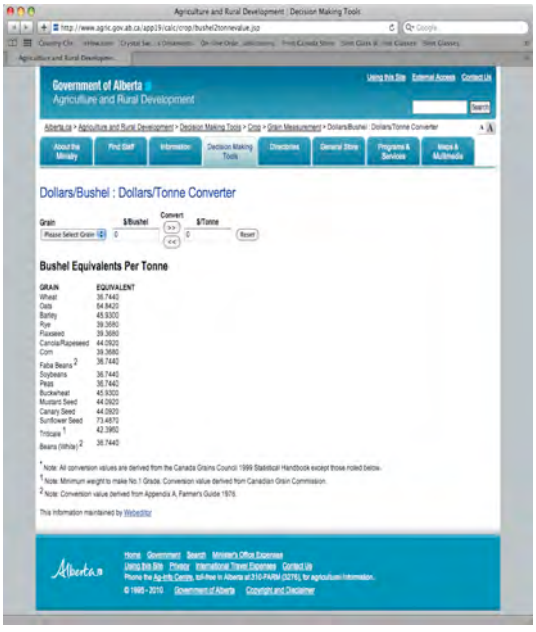
Table 29. Example of the price basis for various locations (Nov-Dec 2010)

Location	Future Basis for Oats going to Minneapolis	
Starbuck, Manitoba	$36.96/tonne	$0.57/bushel
Yorkton, Saskatchewan	$56.71/tonne	$0.87/bushel
Lamont, Alberta	$78.61/tonne	$1.21/bushel

(Anderson, B., personal communication)

Many of the pony oats from Alberta are sent to Oregon through Vancouver (Mitchell Fetch, J., personal communication). The price of the pony oats is also likely to give great variation depending on the buyer. Some buyers of pony oats will pay high prices for good quality oats.

For a price determining calculation see the appendix.



Marketing

There are two choices of marketing for non-board crops pricing (AAFRD, 2010):

1) The cash (spot market) market
2) The contract market

Cash Market

- Requires delivering the crop to a local elevator, neighbor, feedlot, feedmill or grain company.
- Buyers quote a cash price on day of delivery, or a few days before.
- Companies may pick up farm gate sales and charge a delivery price.
- Pony and milling oats often sold on a cash market, you can submit samples to potential buyers to seek the best price.
- Pony oats can be marketed directly to United States buyers using American companies or brokers to arrange the export of the goods (AAFRD, 2010).

Contract Market

- Contracts are normally signed before seeding between November and March.
- Products not meeting the grade specified in the contract will receive a price deduction.
- There is the option to buy out your contract and sell on the cash market (Alberta Oats Rep, personal communication)
- The most popular contract in oat production is a deferred delivery contract. This provides more pricing options, through utilizing futures prices. (Hart, 2009)

Table 30. Summary of oat contracts (More information on contracts in the Appendix)

Before Delivery Contracts
Production Contract • Agreement where producer delivers specified acreage of production • Does not specify price or value • May state minimum quantity and grade • May have maximum quantity for guaranteed acceptance
Deferred Delivery Contracts (DDC) • Producer delivers specified amount on specific date • Purchaser agrees to amount and price on a specific day • Grade usually determined and deductions can be made if unacceptable
Pre-Price Dealer Car Contract • Same as DDC only uses forward pricing • Producer must load the rail car with grain
Farm Gate Purchase Contract • Similar to DDC • Prices grain at a later date • Grain company organize pick up from farm
Supply Contract • Un-priced contract, producer agrees to deliver certain tonnage • Buyer guarantees acceptance of delivery during specified month • Price determined using spot market on the day of delivery
Open Basis to Arrive Contract • Un-priced • Producer guarantees delivery of certain amount in a certain month • Payment based on futures price • Basis not finalized when contract signed • Basis can be locked in by producer any time up to day of delivery
After Delivery Contract
Deferred Pricing Contracts • Producer can deliver grain and accept a partial payment immediately • Producer agrees to final price on or before deadline date
Cash for Futures Contract • Producer delivers grain and locks in price immediately or a few days after delivery • Payment of at least 50% of value day it is priced • If the price increases, producer profits from increase • If the price decreases, losses can be covered by 50% held by grain company • Producer's choice to lock in future price creating gains or losses
Before or After Delivery Contracts
Target-Pricing Contracts • Producer states price they would prefer to receive for specified amount • If grain reaches the desired price automatically paid out
Basis Contract (Grain price order) • Guarantees a basis above or below futures price • Producer can lock futures price before a specified date

Crop Return Comparison

Determines the return on investment for a particular crop in a growing season. The crop with the highest yield or the highest price is not always the most profitable crop for producers to grow. High input costs can easily decrease the profitability of a crop. To assist in determining your return there are regional calculators available:

Alberta

Saskatchewan

Manitoba

Cost of machinery

Table 31.Oats vs feed barley crop return comparison.

Direct seeded stubble crops			
		Oats	Barley
REVENUE PER ACRE			
Estimated Yield (bu/ac) A		74.13	58.9
Estimated On Farm Market Price/bus,lb (B)		2.19	2.96
Estimated Gross Revenue/ac (AxB) (C)		162.72	174.34
Inputs			
Seed		11.55	8.48
Fertilizer	Nitrogen	24.6	24.6
	Phosphorous	9.6	9.6
	Sulfur & other	0	0
Chemical	Herb	12.83	22.91
	Fung/insect	0	0
	others	3.06	2.38
Machinery	Fuel	10.08	10.08
	Repair	6.18	6.18
Custom/Hired Work		8.13	8.13
Crop insurance		9.33	8.25
Utilities and Misc.		5.66	5.66
Interest on Variable expense		1.58	1.65
Total Variable Expenses		102.6	107.92
Other Expenses			
Building Repair		1.6	1.6
Property Tax		6.53	6.53
Insurance & Licenses		2.6	2.6
Machinery Depreciation		20.6	20.6

Building Depreciation	1.6	1.6
Machinery Investment	6.39	6.39
Building Investment	1.3	0.99
Land Investment	21.2	21.2
Total Other Expenses	61.51	61.51
Labor and Management		
Total Expenses	164.51	169.43
Return Per Acre		
Return Over Variable expenses (C-D)	66.44	60.14
Return Over Total Rotational Expenses	-1.37	4.39
Break Even Yield per Acre		
To Cover Variable Expenses	36.5	46.8
To Cover Rotational Expenses	57.2	74.9
Break Even Price Per Bu/lb		
To cover Variable Expenses	1.83	1.38
To cover Rotational Expenses	2.88	2.21

(Saskatchewan Ministry of Agriculture, 2010).

Grading

Primary Grading Tables for Canada Western (CW) and Export Oats

(Retrieved from Grain Grading Guide 2010 Chapter 7: Oats)

Table 32. Primary Grading Tables for Canada Western (CW) and Export Oats

Grade	Standard of Quality		Hulless %	Damage				
	Min. test weight kg/hl (g/0.5 L)	Degree of Soundness		Fireburnt %	Frost %	Fusarium %	Heated/ Rotted %	Total %
No. 1 CW	56 (260)	Good color, 98% sound groats	6	Nil	0.1	0.1	Nil	2
No. 2 CW	53 (245)	Good color 96% sound groats	8	Nil	4	2.0	0.1	4
No. 3 CW	51 (235)	Fair color 94% sound groats	20	Nil	6	4	0.5	6
No. 4 CW	48 (220)	92% Sound groats	No limit	0.25	No limit	6	1	8

Table 33. Foreign material determining grade for Canada Western (CW) and Export Oats

	Foreign Material										
Grade	Barley%	Wheat %	Other cereals grains %	Wild Oats%	Total	Large seeds %	Sclerotinia %	Stones %	Ergot %	Excreta %	Total Foreign Material %
No. 1 CW	0.75	0.75	1	1	3	0.2	Nil	0.017	Nil	0.005	2
No. 2 CW	1.5	1.5	2	2	4	0.3	0.025	0.066	0.025	0.01	4
No. 3 CW	3	3	3	3	6	0.5	0.025	0.15	0.025	0.02	6
No. 4 CW	8	8	8	8	14	1	0.05	0.15	0.05	0.02	8

(CGC, 2010)

Table 34. Determination of commercially clean

Grade	(1) Total material through No. 4.5 round hole sieve %	(2) Small seeds %	(3) Large Seeds through No.5 Buckwheat sieve %	(4) (1) + (3) Total removable material %
No. 1CW	0.2	0.10	0.2	0.2
No. 2 CW	0.2	0.10	0.2	0.2
No. 3 CW	0.2	0.10	0.2	0.2
No. 4 CW	0.2	0.10	0.2	0.2

(CGC, 2010)

Determination of Commercially Clean

- Dockage not assessed on samples that meet commercially clean standards.
- Samples must be analyzed if commercially clean standards before dockage assessment (Visual assessment).
- Any doubt on the sample being commercially clean must be analyzed.

Determination of Dockage

Dockage is defined as, "*any material intermixed with a parcel of grain, other than kernels of grain of standard of quality fixed by or under this Act for a grade of that grain, that must and can be separated from the parcel of grain before that grade can be assigned to the grain*" (CGC, 2010).

Cleaning of Grade Improvement

Cleaning can improve the grade of the delivery. "*Cleaning for grade improvement can be done at any time after assessment has been completed*" (CGC, 2010).

Grading Factors

Damage (DMG)

"*Kernels considered damaged if groats are: fireburnt, heated, frost-damaged, insect damaged, sprouted, mildewed, green, badly weather stained, affected by fusarium or otherwise damaged.*" (CGC, 2010)

Fusarium damage

- Fusarium damage is rare in oats,
- Kernels are discolored, often with pink and black coloration, surrounded by white mould.

Mildew

Table 35. Mildew discoloration

If the discoloration is…	**The sample is considered…**
On the groats, from mildew	Damaged
On the hull, but groats are damaged	Superficially mildewed, but sound

(CGC, 2010)

Sclerotinia sclerotiorum

- Hard black fungal body
- Can vary in size and shape
- Course textured surface

Hulless oats

- Hulless oats have loose hulls usually removed during harvest
- If unprocessed oats contain 75% or more hulless oats, the grade is changed to *Oats, No. 1 CW/CE Hulless.*

Export Shipments

Export shipments are typically commercially cleaned, however it is not always required.

Commercially Clean

- Must meet specification of export grade determinant table upon following the determination of commercially clean (See determination of commercially clean).

Not Commercially Clean (NCC)

- Shipments that do not meet commercially clean standards (See determination of commercially clean).
- These shipments are permitted for export with permission of the CGC

Grading on Exported Oats

- Western oats for export are graded using the Canada West Grading Guide.

Frost and Hail Damage

-Frost injury

- Hail Injury

- Hail damage

Risks

Frost

- Oats are less tolerant to frost in comparison to wheat and barley.
- Early frost decreases the seed quality at harvest time (Saskatchewan Ministry of Agriculture, 2008a).
- Temperatures of -1°C lasting 3-4 hours may cause damage.
- The longer temperatures are below -2 to -3 °C the more likely a "*killing frost*" will occur (Phelps, Unknown).
- Usually it takes 24-48 hours to determine the severity of frost, however this is prolonged in cool, damp weather.
- Shallow seeding increases emergence and decreases frost stress.

Symptoms of Frost

- The critical part to look at on the plant is the seed head.
- *In the flowering stage*: it is unlikely there will be further seed development.
- *In the seed filling stage*: the plant is more mature and less susceptible to frost, however quality and vigour of the seed will be decreased (Saskatchewan Ministry of Agriculture, 2008e).
- Damage appears in the form of watery leaves, pods and seeds that have lost rigidity (Saskatchewan Ministry of Agriculture, 2008 e).
- Another indicator is if the crop turns white color (Phelphs, Unknown).
- Seeds that have been exposed to frost should be tested for vigour.
- Seeds exposed to frost are known to suffer from seed rots and seed blights (Saskatchewan Ministry of Agriculture, 2008 a).

Table 36. Categories of Frost Damage

Type A	Sound seeds with no apparent damage from frost
Type B	Some amount of bran frost
Type C	Moderate frost damage. Kernels may show slight shrivelling, but retain reasonable weight
Type D	Kernels severely damaged by frost. Kernels are substantially shrunken of shrivelled. Low bushel weight.

***Type B,C, and D described above are known to impact crop germination and emergence.
(Saskatchewan Ministry of Agriculture, 2008a)

Hail damage

- Some varieties are less susceptible to hail damage, due to decreased shattering in the event of light, frequent hail storms.
- Oats at tillering stages will recover from severe hail, as only the leaves are affected.
- With loss of leaf tissue there will be a greater effect on yield.
- Hail damage beyond the end of tillering will affect the growing point will drastically lower the yield (AAFRD, 2002).

Recovery

- Growth of new tillers from crown buds shows signs of recovery.
- Recovery decreases as the crop stage advances.
- Severely damaged crops may be salvaged through silage and hay, keeping in mind nitrate levels may be high (See nitrate poisoning).

Crop Rotations

What is your crop history?

- Are there any disease or insect pressures that target a specific crop type?
- What was planted there last year?
- Are there any herbicide residues?

Are there problem weeds?

- Are there volunteers from the previous crop?
- Is there a wild oat problem?
- Are there any herbicide resistant weeds?
- Are the main weed problems broadleaf or grass? (Saskatchewan Ministry of Agriculture, 2004)

Benefits of Crop Rotations

- Including a crop rotation on your farm can diversify your options and can allow for a wider window during seeding and harvesting (AAFC, 2004).
- Using crop rotations can decrease the herbicide resistant weeds in your field (AAFC, 2004).
- Increased utilization of nutrients in the soil as different crops use different types and sources of nutrients at different depths.
- Straw trash will also be changed yearly, which will decrease disease pressure.
- There can be potential increases in yield and profitability.
- Crop rotations can increase water use efficiency as different crops use moisture from different depths in the soil profile (Saskatchewan Ministry of Agriculture, 2004).

Table 37. Crops utility of soil moisture

Soil Moisture Level	Crops
Shallow	Peas, Flax, Lentils
Moderate	Cereals, Canola, Mustard
Deep	Forage, Sunflower, Safflower

(Saskatchewan Agriculture and Food, 2005)

- With different rest periods between crops there is a decreased risk of disease.

Table 38. Rest periods in rotation to decrease disease pressure

Disease	Recommended Rotations
Common Root Rot	2-3 Years
Fusarium Head Blight	2-3 Years
Leaf Spots	2-3 Years
Take-all	1 Year

(Saskatchewan Ministry of Agriculture, 2005)

Table 39. Effects of crop stubble on yield

Crop	Pea Stubble	Cereal Stubble	Oilseed Stubble
Pea	-	High	Moderate
Cereal	Very High	-	High
Canola	High	Moderate	-
Flax	High	Moderate	Moderate

(Growing Knowledge, 2008)

- Growing a cereal after a oilseed can increase the performance of the cereal crop by almost 20%, compared to when it is grown following a cereal (AAFC, 2004).

How to create a rotation:

Keeping a crop history sheet will be a key management technique. It will allow you to keep track of problem weeds, and herbicide use (Saskatchewan Ministry of Agriculture, 2004).

An example of a standard rotation would be canola-cereal-peas-cereal. Depending on where you live, you can incorporate favorable crops for your area (Saskatchewan Ministry of Agriculture, 2005).

- Forage crops can be included in the rotation.
- Choose your crops based on pest pressure and the markets (Saskatchewan Ministry of Agriculture, 2004).
- Consider the varietal selection, as different varieties fill different niches. In oats it depends on if you are working with milling or feed oats (See varieties).
- It is also important to remember that flexibility is key in crop rotations
- Changes can be made as long as they are not resulting in repetitive crops such as a cereal-cereal-cereal rotation, or herbicide residues are not an issue (Saskatchewan Ministry of Agriculture, 2005).
- Adding winter cereals to the rotation can lead to a greater control of weeds, and disrupting the disease cycle (AAFC, 2004).

Water Use

Oats are a water-loving crop that benefit with adequate water supply. It uses the most water out of all the cereal crops (AAFC, 2004). Oats do not excel in the brown soil zones, and have higher yields in the dark brown to black soil zones (Saskatchewan Ministry of Agriculture, 2005). In areas with excess moisture, you can choose to drain the soil, or grow crops such as oats, soybeans, and canary grass. These crops will help to remove the excess moisture (Carvers, Unknown).

In areas with water deficiency, conservation methods should be put into effect. Theses methods may include trapping the snow with reduced tillage, and choosing crops such as; cereals, peas and millet, as they will maintain soil water levels (Carvers, Unknown).

Table 40. Water use of crops

Amount of Water	Crop
Small intake	Pulses, Flax
Moderate intake	Cereals, and Canola
Large intake	Sunflowers, corn, oats, soybeans, canary grass.

(Cavers, Unknown)

Irrigation

Even though oats do require a lot of water it may not be economically efficient to irrigate oats (AAFC, 2004).

Within the prairies there are limited amount of oats grown under irrigation. For the most part it is grown when it is needed for a rotation or as a source of feed (Canada-Saskatchewan Irrigation Diversification Centre, 2009)

References:

Introduction References:

1. Hoffmann, LA. 1995. **World production and use of oats.** In: Welch RW (ed) The oat crop-production and utilization. Chapman and Hall, London, 34–61
2. McMullen, M.S. 2000. **Oats.** p. 127-148. *In* K. Kaulp and J.G. Ponte (eds.) Handbook of cereal science technology. Marcel Dekker, New York, NY.
3. Statistics Canada (2010) **Total Stocks of Principal Field Crops at July 31**. www.statcan.gc.ca.
4. Saskatchewan Ministry of Agriculture. 2010. **2010 September Estimate of Production.** Statistics Fact Sheet. www.agriculture.gov.sk.ca.
5. Willenborg C. 2004. **Characterizing tame oat (*Avena sativa* L.) competitive response to wild oat (*Avena fatua* L.) interference**. Thesis for a Degree of Master of Science. University of Saskatchewan
6. Zechner, E. Buerstmayr, H., Achleitner, A., Tinker, N.A. 2008. **Genetic diversity among oat varieties of worldwide origin and associations of AFLP markers with quantitative traits**. Theor Appl Genet. 117: 1041–1053

Variety References:

1. Alberta Agriculture, Food and Rural Development. 2010a**. Agronomic Crop Performance 2010**. http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex4069/$FILE/cereals.pdf
2. Alberta Agriculture, Food and Rural Development. 2010b. **Alberta Cereal and Oilseed Variety Testing Program.** http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex4069/$FILE/cereals.pdf
3. Manitoba Co-operator. 2009. **Oats and Milling Oats**. Seed Manitoba 2010. Pages 18-22. http://www.agcanada.com/seedmanitoba2010/
4. Manitoba Agriculture, Food and Rural Initiatives. 2001. **Nutrition Differences Among Oat Hulls of Different Varieties.** http://gov.mb.ca/agriculture/livestock/nutrition/bza15s05.html
5. Mitchell Fetch, J. 2010. Personal communication.
6. Saskatchewan Ministry of Agriculture. 2010. **Varieties of Grain Crops 2010**. The Western Producer. http://www.agriculture.gov.sk.ca/Default.aspx?DN=9d4a928f-f7f2-45c9-87af-92fb97b9c567
7. Saskatchewan Ministry of Agriculture. 2005. **Principles and Practices of Crop Rotation.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=f09717b0-cd32-45a2-9276-75e67b4cd1f6
8. SeCan. 2006a. **AC Jordan**. Technical Bulletin. http://www.secan.com
9. SeCan. 2006b. **AC Kauffman**. Technical Bulletin. http://www.secan.com
10. SeCan. 2006c. **AC Lu**. Technical Bulletin. http://www.secan.com
11. SeCan. 2006d. **AC Morgan**. Technical Bulletin. http://www.secan.com
12. SeCan. 2006e. **AC Murphy**. Technical Bulletin. http://www.secan.com

13. SeCan. 2006f. **Ronald**. Technical Bulletin. http://www.secan.com
14. SeCan. 2010. **New Varieties**. Fall 2010. http://www.secan.com
15. University of Saskatchewan. 2010a. **Request for Support of Registration of OT3009.** http://agbio.usask.ca/uploads/gjg533/cdc_solfi_reg_proposal.pdf
16. University of Saskatchewan. 2010b. **Request for Support of Registration of OT3017**. http://agbio.usask.ca/uploads/gjg533/CDC%20SO-I.pdf
17. University of Saskatchewan. 2010c. **Request for Support of Registration of OT3037.** http://agbio.usask.ca/uploads/gjg533/cdc%20varieties/OT3037%20Registration%20Proposal.pdf
18. University of Saskatchewan. 2010d. **Request for Support of Registration of OT3039.** http://agbio.usask.ca/uploads/gjg533/cdc%20varieties/OT3039%20Registration%20Proposal.pdf
19. University of Saskatchewan. 2010e. **Request for Support of Registration of OT3044.** http://agbio.usask.ca/uploads/gjg533/cdc%20varieties/OT3044%20Registration%20Proposal.pdf

Macronutrient References:

1. Alberta Agriculture, Food and Rural Development. 2008. **Lodging of Cereal Crops**. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/crop1271
2. Alberta Agriculture, Food and Rural Development. 2000. **Potassium Fertilizer Application in Crop Production** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex917
3. Cambell, C. A and Jalil, A. 1996. **Values Estimated with ENR equations**. Alberta Agriculture Field Research.
4. Dyck, M. 2010. Personal Communication.
5. Eriksen, J and Hall, M. R. 2000. **Sulfur Fertilizer Application in Crop Production.** Alberta Agriculture, Food and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3526
6. Grant, C.A., D.N. Flaten, D.J. Tomasiewicz, and S.C. Sheppard. 2001. **The Importance of Early Season Phosphorus Nutrition**. Can. J. Plant Sci. 81:211-224.
7. Jackson, G. D., Berg, R. K., Kushnak, G. D., Blake, T. K. and Yarrow, G. I. 1994. **Nitrogen Effects on Yield, Beta-glucan Content, and other Quality Factors of Oat and Waxy Hulless Barley.** Commun. Soil Sci. Plant Anal. 25: 3047–3055.
8. Manitoba Agriculture, Food and Rural Initiatives. 2010. **Oat Production and Management**. http://www.gov.mb.ca/agriculture/crops/cereals/bfc01s01.html
9. Marshall, H. G., Kolb, F. L. and Roth, G. W. 1987. **Effects of Nitrogen Fertilizer Rate, Seeding Rate and Row Spacing on Semi-dwarf and Conventional Height Spring Oat.** Crop Sci. **27**: 572–575.

10. May, W. E., Mohr, R. M., Lafond, G. P., Johnston, A. M. and Stevenson, F. C. 2004.. **Effect of Nitrogen, Seeding Date and Cultivar on Oat Quality and Yield in the Eastern Canadian Prairies**. Can. J. Plant Sci. **84**: 1025–1036.
11. McKenzie, R. 2010. Personal Communication
12. McKenzie, R. and Middleton, A. 1997. **Phosphorus Fertilizer Application in Crop Production**. Alberta Agriculture, Food and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex920
13. McKenzie, R. 2006. **Soil Fertility and Crop Nutrition- A Balanced Approach.** Alberta Agriculture, Food and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ind10748
14. Mohr, R. M, Grant, C. A., May, W. E., and Stevenson, F. C. 2007. **The Influence of Nitrogen, Phosphorus and Potash Fertilizer Application on Oat Yield and Quality.** Canadian Journal of Soil Science.87: 459-468. http://www.gov.mb.ca/agriculture/crops/cereals/bfc01s01.html
15. Saskatchewan Ministry of Agriculture. 2009. **Nitrogen Fertilization in Crop Production**. http://www.agriculture.gov.sk.ca/Default.aspx?DN=974dcb32-20a8-4086-b2a8-4ee083ad4fdb
16. Saskatchewan Ministry of Agriculture. 2006. **Phosphorus Fertilization in Crop Production**. http://www.agriculture.gov.sk.ca/Default.aspx?DN=8df90666-f056-45c2-8cbd-61348aeb579b
17. Saskatchewan Ministry of Agriculture. 2008. **Potassium Fertilization in Crop Production.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=ee0d4c16-a502-4aa8-9bd7-9abd83e8e3a0
18. Saskatchewan Ministry of Agriculture. 2009. **Sulfur Fertilization in Crop Production.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=1910208b-760e-4582-ac32-56ed8980b5a6
19. Western Canada Fertilizer Association. 2002. **Fertilizer Requirements of Cereal Crops.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/crop4689

Micronutrient References:

1. Haehnel, W. 1984. **Photosynthetic Electron Transport in Higher Plants**. Annu. Rev. Plant Physiol. 35: 659-693.
2. Marschner, H. 1995. **Mineral Nutrition of Higher Plants**, 2nd Edition. Academic Press, London.
3. McKenzie, R. 2010. Personal Communication.
4. McKenzie, R. 1992. **Micronutrient Requirements of Crops.** Alberta Agriculture, Food and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex713
5. Solberg, E., Evans, I., and Penny, D. 1999. **Copper Deficiency: Diagnosis and Correction.** Alberta Agriculture and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3476

Fertility with Manure References:

1. Tri-Provincial Manure Application and Use Guidelines Manual. **The Prairie Provinces' Committee on Livestock Development and Manure Management.** http://www.gov.mb.ca/agriculture/livestock/beef/pdf/baa08s01a.pdf

Climate References:

1. Alberta, Agriculture, Food and Rural Development. 2002. Hail Damage on Cereal Crops. Barley Production in Alberta: Crop Damage. www.agric.gov.ab.ca.
2. Manitoba Agriculture, Food and Rural Initiatives. 2010. **Oat Production and Management**. http://www.gov.mb.ca/agriculture/crops/cereals/bfc01s01.html
3. McLeod. 1982. **Feed the Soil**. Organic Agriculture Research Institute.
4. Miller, D. A. 1984. **Forage Crops**. McGraw-Hill Book Company. New York, United States. Page 530.

Soil Condition References:

1. Alberta Agriculture, Food and Rural Development. 2004. **Alberta Fertilizer Guide.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3894/$file/541-1.pdf?OpenElement
2. Alberta Agriculture, Food and Rural Development. 2001. **Salt Tolerance of Plants.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm7780
3. Saskatchewan Ministry of Agriculture. 2009. Saskatchewan Ministry of Agriculture. 2009. **Nitrogen Fertilization in Crop Production**. http://www.agriculture.gov.sk.ca/Default.aspx?DN=974dcb32-20a8-4086-b2a8-4ee083ad4fdb
4. Evans, L.R. 2003. **Diseases of Oats.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm7780

Growth and Development References:

1. Bayer CropScience. **A Field Guide to Cereal Staging** http://www.bayercropscience.ca/English/ResourcePublication/5/File.ashx
2. Nelson, J. E., Kephart, K. D., Bauer, A., and Connor, J. F. 1995. **Growth Staging of Wheat, Barley and Wild Oat**. Montana State University Misc. Bulletin 4387. http://plantsci.missouri.edu/cropsys/growth.html
3. Stoskopf, N.C. 1985. **Cereal Grain Crops**. Reston Publishing Company, Inc., Reston, Virginia. 22: 444-458.

Weed Management References:

1. Agriculture and Agri-Food Canada. Unknown. **Weed management options which reduce pesticide risk: Seeding date manipulation, Seeding rate and row spacing.**
2. Alberta Agriculture, Food and Rural Development. 2010. **Weeds and Integrated Weed Management for Oats**.
3. Brook, H and Cutts, M. 2010**. Crop Protection 2010**. Alberta Agriculture Food, and Rural Development.
4. Hall, M., 2004. **Integrated weed management principles: Reducing the risk of crop failure**. Alberta Agriculture Food and Rural Development
5. Lanoie, N., D. Pageau, J. Lajeunesse, J. Durand, A. Vanasse, J. Collin and J. Fregeau-Reid. 2010. **Naked oat response to soil type and herbicides applied at two growing stages**. Canadian Journal of Plant Science - Revue Canadienne De Phytotechnie 90:247-255.
6. North Dakota State University.2010. **Foxtail control in oat**. North Dakota State University Extension Service. Pro Crop.

Disease References:

1. Alberta Agriculture, Food and Rural Development. 2009**. Fusarium Head Blight (FHB), Scab, Pink Mold, or White Heads**. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm4518.
2. Alberta Agriculture, Food and Rural Development , 2008a. **Barley Yellow Dwarf Virus, Red Leaf of Oats Barley Yellow Dwarf Virus, Red Leaf of Oats.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2401
3. Alberta Agriculture, Food and Rural Development. 2008b. Smuts and Bunts.
4. Bailey, K.L, Gossen, B.D, Gugel, R.K., and Morrall, R.A.A. 2003. **Diseases of Field Crops in Canada**. Canadian Phytopathological Society. Page 30-88.
5. Canadian Grain Commission. 2010. **Fusarium Head Blight in Western Canada**. http://www.grainscanada.gc.ca/srt-rst/fusarium/fhbwc-foc-eng.htm
6. Chong, J., Gruenke, J., Dueck, R. and Mayer, W. 2009. **Crown Rust of Oat in Western Canada.** Canadian Plant disease survey 89: 76-77.
7. Fetch, T., Dunsmore, K. and Zegeye, T. 2009. **Stem Rusts of Cereal in Western Canada in 2008**. Canadian Plant Disease Survey 89: 67
8. Gill, C.C. 1970. **Epidemiology of Barley Yellow Dwarf in Manitoba and Effect of the Virus on Yields of Cereals**. Phytopathology 60: 1826-1830.
9. Saskatchewan Ministry of Agricultural. 2009. **Crown Rust of Oats – FAQs.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=6d68d85d-ab16-4ea9-95e9-1d5f69b5a1c8
10. Manitoba Agriculture, Food and Rural Initiatives. Unknown a. **Managing Cereal Leaf Diseases.** http://www.gov.mb.ca/agriculture/crops/diseases/fac43s00.html
11. Manitoba Agriculture, Food and Rural Initiatives. Unknown b. **Stem Rust of Wheat Barley and Oats.** http://www.gov.mb.ca/agriculture/crops/diseases/fac15s00.html

12. Manitoba Agriculture, Food and Rural Initiatives. Unknown c. **Barley Yellow Dwarf Virus.** http://www.gov.mb.ca/agriculture/crops/diseases/fac09s00.html
13. McCallum, B.D., Fetch, T. and Chong, J. 2007. **Cereal Rust Control in Canada.** Australian Journal of Agricultural Research 58: 639-647.
14. Menzies, J.G., Wong, B.B., Popovic, Z. and Saramaga, C. 2009. **Cereal Smut Surveys, 2008.** Canadian Plant Disease Survey, 89: 66
15. Tekauz, A., McCallum, B., Ames, N., and Mitchell Fetch, J. 2004. **Fusarium Head Blight of Oat – Current Status in Western Canada**. Can, J. of Plant Pathol. 26: 473-479.
16. Tekauz, A., Mitchell Fetch, J.W., Rossnagel, B.G. and Savard, M.E. 2008. **Progress in Assessing the Impact of Fusarium Head Blight on Oat in Western Canada and Screening of *Avena* Germplasm for Resistance**. 3rd In. FHB Symposium. Pages 49-56.
17. Tekauz, A., Meuller, E., Stulzer , M., and. Beyene, M. 2009a. **Monitoring of Fusarium Head Blight of Oat in Manitoba in 2008**. Canadian Plant Disease Survey 89: 79-80
18. Tekauz, A., Kutcher, H.R., Mueller, E., Beyene, M. and Stulzer, M. 2009b. **Leaf Spot Diseases in Manitoba and Saskatchewan Oat Crops in 2008**. Canadian Plant Disease Survey. 89: 81-81

Natural Enemies References:

1. **Alberta Agriculture, Food and Rural Development. 1986.** Natural Enemies of Field Crop Insect Pests in Alberta. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1157

Insect References:

1. Alberta Agriculture, Food and Rural Development. 2008a. **Greenbug**. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2498
2. Alberta Agriculture, Food and Rural Development. 2006b**. Prairie Grain Wireworm.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2509?opendocument
3. Alberta Agriculture, Food and Rural Development. 2006c. **Grasshoppers-Clear Winged.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2480?opendocument
4. Alberta Agriculture, Food and Rural Development. 2008d**. Economic Thresholds for Insects Attacking Cereal and Corn.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2474
5. Canadian Food Inspection Agency. 2006. ***Oulema melanopus* L. Cereal Leaf Beetle.** http://www.inspection.gc.ca/english/plaveg/pestrava/oulmel/tech/oulmele.shtml
6. Dosdall, L. 2010 Personal communication
7. Government of British Columbia, unknown, **Cereal Leaf Beetle**. http://www.agf.gov.bc.ca/cropprot/clbeetle.htm

8. Hodgson, E..W. and Evans, W.E. 2007. **Cereal Leaf Beetle – Utah Pests Fact Sheet.** http://extension.usu.edu/files/publications/factsheet/cereal-leaf-beetles07.pdf
9. Karren, J.B. **Russian Wheat Aphid in Utah** - Utah State University Extension. Fact Sheet No. 67. http://extension.usu.edu/files/factsheets/russian2.pdf
10. Manitoba Agriculture, Food and Rural Initiatives. Unknown a. **Aphids on Cereals.** http://www.gov.mb.ca/agriculture/crops/insects/fad05s00.html.
11. Manitoba Agriculture, Food and Rural Initiatives. Unknown b. **Wireworms.** http://www.gov.mb.ca/agriculture/crops/insects/fad28s00.html
12. Manitoba Agriculture, Food and Rural Initiatives. 2009c. Cutworms in field crops. http://www.gov.mb.ca/agriculture/crops/insects/fad06s00.html
13. Peairs, F.B. 2008. **Wheat Pests and their Management**. Encyclopaedia of Entomology. Part 23: 4220-4238.

Seeding Management

1. Becker, R.L., Swanson, D.R., Millerm D.W. and Sheaffer, C.C.. 1998. **Forage quality and economic implications of systems to manage giant foxtail and oat during alfalfa establishment**. J. Prod. Agric. 11:300-308.
2. Curran, B.S., Twidwell, E.K. and. Kephar,t K.D. 1993. **Oat companion crop management in alfalfa establishment**. Agron. J. 85:998-1003.
3. Gooding, R.W. and Lafever, H.N.. 1991. **Yield and yield components of spring oat for various planting dates**. J. Prod. Agric. 4:382-385.
4. Lanini, W.T., Marble, V.L., Grattan, S.R, Vargas, R.N., Orloff, S.B. and Orr, J.P. 1991. **Oat companion crop seeding rate effect on alfalfa establishment, yield, and weed control**. Agron. J. 83:330-333.
5. May, W.E., Johnston, A.M., Stevenson, F.C., Mohr, R.M. and Lafond, G.P. 2004**. Early seeding dates improve oat yield and quality in the eastern prairies**. Canadian Journal of Plant Science - Revue Canadienne De Phytotechnie 84:431-442.
6. May, W.E., Johnston A.M., Stevenson, F.C., Mohr R.M., and Lafond, G.P. 2004. **Effect of nitrogen, seeding date and cultivar on oat quality and yield in the eastern canadian prairies**. Canadian Journal of Plant Science - Revue Canadienne De Phytotechnie 84:1025-1036.
7. May, W.E., Holzapfel, C.B., Lafond, G.P. Shirtliffe, S.J and McAndrew, D.W. 2009. **Management of wild oat (*avena f,atua* L.) in tame oat (*avena sativa* L.) with early seeding dates and high seeding rates**. Canadian Journal of Plant Science - Revue Canadienne De Phytotechnie 89:763-773.
8. Nass, H.G., Sterling, J.D.E., MacLeod J.A., and Johnston, H.W. 1975. **Effects of seeding date, seed treatment and foliar sprays on yield and other agronomic characters of wheat, oats and barley**. Canadian Journal of Plant Science. Pages 41-47.
9. O'Donovan, J.T., Dosdall, L.M., Maurice, D.C., Turkington, T.K., Moyer, J.R. Blackshaw, R.E.,. Harker K.N, and. Clayton G.W. 2007. **Integrated approaches**

to managing weeds in spring-sown crops in Western Canada. Crop Protection 26:390-398.
10. Ontario Ministry of Agriculture, Food and Rural Affairs Staff. 2009. **Cereals: Planting and crop development**. OMAFRA.
11. Willenborg, C.J., S.J. Shirtliffe and B.G. Rossnagel. 2005. **Oat caryopsis size and genotype effects on wild oat-oat competition.** Crop Sci. 45:1410-1416.
12. Willenborg, C., Lafond, G., Shirtliffe S.J., May W.E. and Gulden R.H. 2005. **Influence of wild oat (*avena fatua*) relative time of emergence and density on cultivated oat field, wild oat seed production, and wild oat contaminatio**n. Weed Sci. 53:342-352.
13. Willenborg, C.J., Lafond, G.P., Shirtliffe, S.J., Rossnagel, B.G. and May W.E. 2005**. Effects of relative time of emergence and density of wild oat (avena fatua L.) on oat quality**. Canadian Journal of Plant Science - Revue Canadienne De Phytotechnie 85:561-567.

References for Intercropping:

1. Chalmers, S., and Day, S. 2009. **Potential of Intercropping Peas and Oats for Grain and Silage Production**. Manitoba agriculture Food and rural Initiatives, Westman Agricultural Diversification Organization. http://www.umanitoba.ca/afs/agronomists_conf/Posters/Chalmers_oat_pea_poster.pdf

Oats for Grain

1. Alberta, Agriculture, Food and Rural Development. Unknown. **Grain Storage – Frequently Asked Questions**. www.agric.gov.ab.ca.
2. Clark, J.M. 1984. **Effect of seeding rate and time of harvest on losses of oats in windrower/combine and direct combine harvest systems.** Canadian Journal of Plant Science. 64: 31-35.
3. May, W.E., Stevenson, F.C., Lafond, G.P., and Mohr, R.M. 2005. **Oat quality and yield as affected by kernel moisture at swathing**. Canadian Journal of Plant Science. 85; 4: 839-846.
4. Molteberg, E. L., Solheim, R., Dimberg, L. H., and Frølich, W. 1996. **Variation in oat groats due to variety, storage and heat treatment.** II: Sensory quality. Journal of Cereal Science. 24: 273-282.
5. Monsanto. Unknown. Crop **Protection; Product Use; Pre-Harvest**. www.monsanto.ca.
6. Prairie Oat Growers Association. Unknown. **Harvest Management**. Oat Grower Manual: Harvest. www.poga.ca.
7. Saskatchewan Ministry of Agriculture. 2008. a. Effect **of Fall Frost on Seed Quality**. Production Fact Sheet. www.agriculture.gov.sk.ca.
8. Saskatchewan Ministry of Agriculture. 2008. b. **Insects and Mould in Stored Grain – Insect, Control: Prevention**. Production Fact Sheet. www.agriculture.gov.sk.ca.

Oats for Forage

1. Saskatchewan Ministry of Agriculture. 2008 c. **Annual Crops for Greenfeed and Grazing. Production – Livestock: Feed/Nutrition.** www.agriculture.gov.sk.ca.
2. Saskatchewan Ministry of Agriculture. 2008 d. **Silage Storage Techniques**. Production Fact Sheet. www.agriculture.gov.sk.ca.

Post Harvest

1. Borresen, T. 1999. **The effect of straw management and reduced tillage on soil properties and crop yields of spring sown cereals on two loam soils in Norway**. Soil and tillage research. 51 (1/2): 91-102

Oat Future Market

1. Market Analysis group: Grains and Oilseeds Division. 2010**. Oats: Situation and Outlook**. Agriculture & Agri-Food Canada. http://www.agr.gc.ca/pol/maddam/index_e.php?s1=pubs&s2=rmar&s3=php&page=rmar_02_03_2010-08-03

Oat Market References:

1. Alberta Agriculture, Food and Rural Development. 2010**. Marketing Oats in Canada.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis10952
2. Bouphasiri, Chanchoura and Verchomin ,and Stefan. 2005. **A Case Study of the Canadian Oat Market: the evolution from the central desk system to the open market.** http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/choice13151/$FILE/OatsStudyNov2005.pdf
3. Market Analysis group: Grains and Oilseeds division. 2010. Oats: **Situation and Outlook. Agriculture & Agri-Food Canada.** http://www.agr.gc.ca/pol/maddam/index_e.php?s1=pubs&s2=rmar&s3=php&page=rmar_02_03_2010-08-03
4. Mitchell Fetch, J. 2010. Personal communication.
5. Micheal Tembly et al. 2010**. Hay Market**. Saskatchewan agriculture http://www.agriculture.gov.sk.ca/Default.aspx?DN=b15adc61-9839-40d5-808b-bbef7b95f8c5

Pricing References:

1. Anderson, B. 2010. Personal Communication
2. Alberta Agriculture, Food and Rural Development. 2010. **Marketing Oats in Canada.** http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis10952
3. Bouphasiri, Chanchoura and Verchomin, Stefan. 2005. **A Case Stud of the Canadian Oat Market: the evolution from the central desk system to the open market.**

http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/choice13151/$FILE/Oats StudyNov2005.pdf
4. Mitchell Fetch, J. 2010. Personal communication.

Contract References:

1. Alberta Agriculture, Food and Rural Development. 2010. **Open Market Crop contracts**. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis10994
2. Alberta Oats Sales Representative. 2010. Personal Communticaion
3. Hart, L. 2009. Many Crop Contracts for 2010. Ag Canada.

Grading References:

1. Canadian Grain Commission. 2010. **Official Grading Guide: Chapter 7 Oats.** http://www.grainscanada.gc.ca/oggg-gocg/07/oggg-gocg-7-eng.htm \

Risk References:

1. Alberta, Agriculture, Food and Rural Development. 2002. **Hail Damage on Cereal Crops. Barley Production in Alberta: Crop Damage**. www.agric.gov.ab.ca.
2. Phelphs, S. Unknown. **Frost Damage to Crops.** Saskatchewan Agriculture, Food and Rural Revitalization. www.agriculture.gov.sk.ca.
3. Saskatchewan Ministry of Agriculture. 2008 a. **Effect of Fall Frost on Seed Quality**. Production Fact Sheet. www.agriculture.gov.sk.ca.
4. Saskatchewan Ministry of Agriculture. 2008 e. **Early Frost and Nitrates - FAQs. Production Fact Sheet.** www.agriculture.gov.sk.ca.

Crop Rotations References:

1. Saskatchewan Ministry of Agriculture. 2005. **Principles and Practices of Crop Rotation.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=f09717b0-cd32-45a2-9276-75e67b4cd1f6
2. Growing Knowledge. 2008**. Canola in Rotation**. Agronomic Spotlight.
3. Saskatchewan Ministry of Agriculture. 2004. **Cropping Decisions.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=71987997-30df-425c-86da-1466e8732faa
4. Saskatchewan Ministry of Agriculture. 2008. **Things to Consider Before Planting Oats – FAQs.** http://www.agriculture.gov.sk.ca/Default.aspx?DN=17066e3e-fc0a-46fe-bc32-f7144aa5dd17
5. Alberta Agriculture, Food and Rural Development. 2004**. Beneficial Management Practices**. Alberta Agriculture, Food and Rural Development.

Water Use References:

1. Canada-Saskatchewan Irrigation Diversification Centre. 2009**. Crop Varieties under Irrigation.** http://www.irrigationsaskatchewan.com/ICDC/content/2010%20CSIDC%20Variety%20Guide.pdf
2. Cavers, C. Unknown. **Principles of Soil Moisture Management**. MARFI.
3. Saskatchewan Ministry of Agriculture. 2005**. Principles and Practices of Crop Rotation**. http://www.agriculture.gov.sk.ca/Default.aspx?DN=f09717b0-cd32-45a2-9276-75e67b4cd1f6
4. Alberta Agriculture, Food and Rural Development. 2004. **Beneficial Management Practices.** Agriculture Food and Rural Development.

Plant Breeder Rights References:

1. Canadian Food Inspection Agency. 2010. Plant **Breeder Rights Guide.** http://www.inspection.gc.ca/english/plaveg/pbrpov/guidee.shtml
2. Canadian Seed Trade Association. Unknown. **Plant Breeders' Rights.** http://www.cdnseed.org/library/plant_breeders_rights.asp

Appendix A: Plant Breeders Rights

Plant Breeders Rights

Plant Breeders Rights (PBR) are a way for breeders to protect the new varieties. It gives the owner of the variety the right to sell it and reproduce it and to veto other companies from selling or reproducing the material without permission (CSTA).

What Are PBR:

Allows those who develop new varieties to recover some of their costs and reinvest them into research of new material. It also provides control over the sale of these new varieties. This is a very cost effective way to ensure that there is a increase in yields, resistance and market uses.

The PBR were used because as there has been an increase in plant technology there needs to be a way to encourage breeders to continue developing new varieties.

A protected variety means that the farmer receives the best quality seed, which is ensured with government testing and standards.

Farmers may keep their seed for the following year, but they are not allowed to sell it as seed to another other producer (CSTA).

These are the actual offenses found in the PBR Act:

> "It is an offence for any person, when selling a variety, to not use the registered denomination for that variety (i.e. the denomination under which the variety was granted rights); to use another denomination for the variety, or one that has been registered for another variety or could be confused with a registered denomination; or to falsely claim that the variety is a protected variety.
>
> It is an offence for any person to make false representation, make a false entry in the register, falsify documents, or produce any false documentation."
>
> (CFIA, 2010)

Failing to follow the rules and guidelines can result in fines, and jail time.

Appendix B: Price Calculations

For a calculator to convert Dollars/ tonne to Dollars/bushel check out:
http://www.agric.gov.ab.ca/app19/calc/crop/bushel2tonnevalue.jsp

Oats, Canada Western Minimum Test Weights

	g/ 0.5L	Kg/hL	*Avery Bushell (Can) lb/bu	*Winchester (U.S.) lb/bu
No. 1 CW	260	56	44.9	40.4
No. 2 CW	245	53	42.5	38
No. 3 CW	235	51	40.9	36.5
No. 4 CW	220	48	38.5	34.1

* CBOT and Westerm Producer prices are based on Oats, No.2 CW

CBOT Price Determining Calculation

CBOT Price $US/winch. Bushel		Min No.2 CW *winch. Bushel		lb to kg		Kg to ton	
2.6	x	1/38	x	2.2046	x	1000	=

$US/ton		Exchange rate US/Can		$CAD/ton		**Price Basis (Lamont) $/t	
208.856842	x	0.979	=	204.4708484	-	78.61	=

Producer Price Received $CAD/Ton		Convert to $/*Avery bushell		$CAD/ *Avery Bushel
125.8608484	x	0.0192776	=	2.426295092

Western Producer Based Price Calculation

$CAD/bushel (Western Producer December 3, 2010)		Basis Price $CAD/bu Lamont Alberta		$CAD/ Avery Bushel
3.68	-	1.21	=	2.47

*Note the US uses a winchester bushel while Canada uses the avery bushel. Avery bushel is a little larger to account for compaction, see beginning of Figure for values.

**Canadian producers can also sign up to Oat insight at http://www.oatinsight.com/oatshome/grow_cdn_index.html, for $200 per year. This website provides the price and basis information for oat millers in Canada. Export, production statistics and other information about the oats market and prices.

Appendix C: Contracts

Types of Contracts	Advantage	Limitations
Production Contract • Producer agrees to deliver some or all production from a number of acres • Purchaser guarantees to accept delivery • Most contracts do not specify price or total volume delivered but may have max guaranteed acceptance. • Conditions vary depending on company • Some state minimum quantity accepted • Some only accept top grade • Some buyers allow pricing of some expected production with deferred delivery or target pricing • Unpriced may be priced at daily cash price on delivery day. • Many also be left unpriced and committed to a basis contract to a target pricing contract or to a deferred contract	- Eliminated risk of restricted delivery opportunities for some or all of crop - No minimum delivery may be required in cases of crop failure	- Does not deal with price risk or basis risk - Limits choice of company you can deliver to - First right of refusal price may mean selling grain through contract for lower price than what is available at grain elevators
Deferred Delivery Contracts (DDC) • Contract agreement by producer to deliver a specific amount of crop by a certain date. • Company agrees to accept delivery of amount and pay specific price on that day of delivery • Usually specify a quality or grade, if lower than specific grade then price deductions are made • Discounts usually agreed upon in initial contract but	- Eliminates the risk of future price declines - Eliminates the risk of restricted delivery opportunities - Does not require margins to lock in a price for future delivery - Are available from local elevators, grain dealers, special crops buyers, some feedlots and feedmills	- The amount of product specified in the contract must be delivered - Limits choice of company to which the grain may be delivered - The contracts do not allow producers to take advantage of later price rises

some specify that discounts given on the delivery day • DDC specify deliver anywhere between a few weeks to twelve months • Most companies allow pre-pricing of part of the expected tonnage prior to harvest • After harvest producer may contract or price entire crop		
Pre-priced dealer car contracts • Similar to DDC except that it is for forward pricing of grain • Producer loads dealer car rather than the elevator or grain dealer.	- Eliminates the risk of future price declines - Eliminates the risk of restricted delivery opportunities - Does not require margins for futures contract accounts - Are available from local elevator managers, grain dealers and some special crop buyers - Dealer cars have a better basis level than elevator delivery and, therefore, offers a larger net return to producers	- The amount of product specified in the contract must be delivered - Limits the choice of company to which the grain may be delivered - Dealer cars usually have a weaker basis level than producer cars for same product - Do not allow producers to take advantage of price increases - Producers must have enough product available to fill a car - Dealer cars like producer cars must be load by the producer - Spotting of cars may be delayed by railway train scheduling - Payment is not received immediately. Payment is made after car unload at the final destination
Farm gate purchase contracts • Similar to DDC, used by farmers to price grain for sale from farm at a later, specified date. • The grain company finds a buyer and	- Eliminates price risk. - No grain hauling by the producer. - Price may be higher than the elevator price due to elimination of elevation charges.	- Load size is unknown until truck unloads - Payment not received until some time after truck unload.

arranges for farm pick-up of the grain. • Producer paid by the grain company based on the unload weight, grade and dockage. • Producers are advised to keep a random sample of grain from each truckload		
Supply Contracts • Un-priced contract • Producer agrees to deliver a certain tonnage of grain during a certain month • Buyer guarantees to accept delivery during the specified month • Buyer may pay producer to store grain on farm but only pays when actually in bins • May be priced out at the time of delivery with spot or street price on the day • May also use DDC to price out before delivery	- Part of the cost of on-farm storage may be paid - Eliminates risk of restricted delivery opportunities	- Amount of product specified in the contract must be delivered - Limits the choice of company to which the grain must be delivered - Does not eliminate price risk
Open Basis or To Arrive contracts • Un priced contract only available for crops with future contract for pricing • Producer guarantees to deliver a certain tonnage of crop at a specific time at a guaranteed futures price • Basis however has not been finalized when contract is signed • Final price determined when seller chooses or locks in basis • Price is then futures price plus or minus basis that was locked in	- Locks in the futures but allow the producer to take advantage of improved basis at later date - Eliminates the risk of restricted delivery opportunities since used prior to delivery - Can be used to lock in a high futures price without using a commodity broker or futures commission merchant - Allows a producer to speculate on strengthening or improving basis levels	- Requires good understanding of basis and factors of influence - Used alone it not totally eliminates cash price risk - Limits the choice of company to which the grain may be delivered - Open-basis contracts are only available for commodities which there are future contracts

• Basis can be locked in at any time up to the day of delivery • Under Canada Grain Act Regulations, no time limit on the length of time crop can remain un-priced on an open-basis contract • For grain that has been delivered, producer must lock in basis and receive payment 90 days after delivery to be covered by grain company's security coverage • Producer must understand basis and factors that influence basis levels before agreeing to open basis contract. See *Basis*-How Cash Grain Prices are Established for more info.(ALBERTA AG.)		
After Delivery Contracts		
Deferred Pricing contracts • Allow a producer to deliver grain and accept a very small partial payment immediately • Producer agrees to final price on or before deadline date specified • DPC's must be priced and full payment received within 90 days of delivery to meet CGC grain-company bonding protection regulations	- Eliminates on-farm spoilage risk - Reduces on-farm storage - Eliminates risk of restricted delivery opportunities at a later date - Allows pricing with just a phone call - Allows producers to take advantage of price improvements within certain time after delivery	- Exposes a producer price risk - Often stronger (narrower basis levels do not apply to grain already delivered on DPC. - The product must be priced-out and payment received within 90 days after delivery to be covered by Canadian Grain Commission bonding protection - A large number of DPCs expiring a short time may force prices downward

Cash-for-futures contracts (CFF) • Unpriced contract only available for crops with future contract for pricing • To use a CFF contract, producer first delivers grain and locks in the price for it either immediately or within a certain number of days of delivery • Producer receives payment for at least 50 percent of the product value that day it is priced • Remaining 50 percent is used by grain buyer to buy an equivalent tonnage of futures contracts on behalf of the producer • If prices rise, producer profits from the increase in value of the contracts • If prices fall the losses are covered by the funds held by the purchasing grain company • Producer must choose a point to close out the futures position and lock in the futures gain or loss • Be sure the buyer is with a Registered Futures Commodity Merchant (RFCM) arm • If the buyer is not with an RFCM arm they could be violating security regulations	• The producer receives partial payment for his crop while waiting for price improvement. • Allows producers to speculate on the futures market without using an RFCM directly. • Allows a producer to lock in a favorable basis, if available, at time of delivery.	- The producer is not protected against futures price risk. - There is significant risk of losing money on any futures trade. - CFF contracts only apply to crops with a futures contract. - The amount per tonne withheld by the grain company is usually higher than the margin - Deposit required on futures contracts required by RFCMs. - There is usually no interest paid on the money withheld by the grain company. - There may be a small administration fee charged by the grain company for each futures contract purchased and sold. - CFF contracts not priced and paid in full by 90 days are not protected by Canadian Grain Commission bonding protection.

Before or After Delivery Contracts		
Basis contracts • A basis contract is an unpriced marketing contract • Producer guarantees to deliver or has already delivered a portion • Guarantee a basis above or below futures price • Producer can lock in futures price before a specified later date • Final price determined using locked in future prices plus or minus the basis specified in the contract	- Locks in basis but allows producer to take advantage of later futures price increases - Eliminates the risk of restricted delivery opportunities if used prior actual delivery - Can be used with the futures market to create a perfect hedge, a hedge with no basis risk - Requires a good understanding of basis and the factors that influence it	- Used alone it does not eliminate price risk - Limits the choice of company which grain may be delivered - Basis contracts on delivered grain not priced and paid in full by 90 days not protected by Canadian Grain Commission bonding protection
Target-pricing contracts • Sometimes called grain pricing order • Producer states the price he would like to receive for a specified amount of product • If grain reaches the price it is automatically priced out • Contract can be used for unpriced grain already delivered or farm stored grain	' The producer specifies the desired price in advance. - The product is priced without constantly watching the market. - Allows producers to "speculate in the bin".	- Marketing decisions are isolated from the producer - The market price could miss producer-selected price by only a few cents, good marketing opportunity could be missed - Prices could rise above the target price but the producer would only receive the target price - Target-pricing contracts are often only in effect for a specified time period, usually 90 days, although some companies will renew them if producer wishes - Not priced and paid in 90 days are not protected by Canadian Grain Commission bonding protection

All information in the table came from the following source:

Alberta Agriculture, Food and Rural Development. 2010. **Open Market Crop contracts**. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis10994