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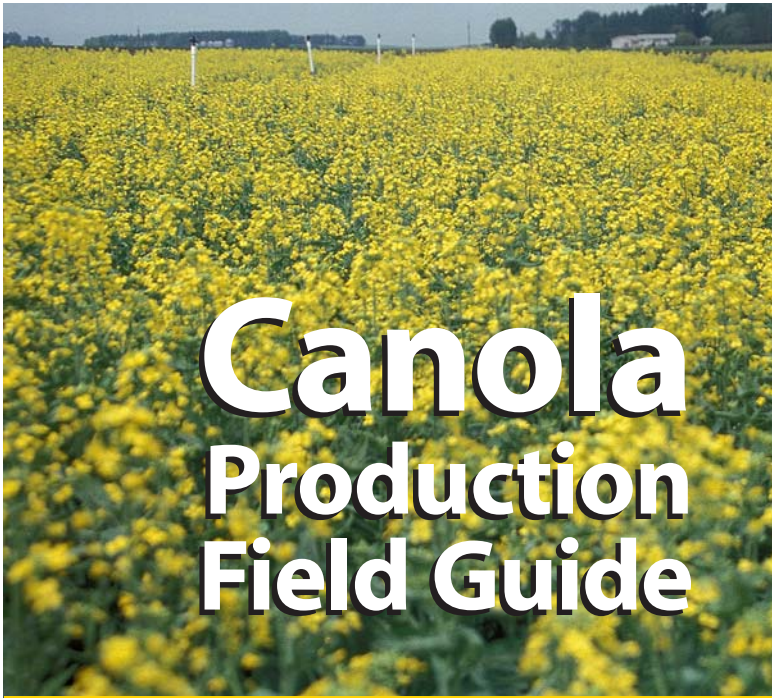

Canola Production Field Guide

FEBRUARY 2005

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For more information on this and other topics, see:
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Introduction

Canola has become a popular oilseed cash crop in North Dakota. North Dakota leads the United States in canola production, with approximately 88 percent of the domestic production. About 780,000 acres were planted in North Dakota in 2004. The highest acreage planted in North Dakota was in 2002, with 1.3 million acres reported. Statewide yields have averaged from 1,250 to 1,500 pounds per acre during the past five years.

Canola is a specific edible type of rapeseed that contains about 40 percent oil. It was developed in the 1970s. The term **"canola"** is a name that the Western Canadian Oilseed Crushers Association has registered.

Canola varieties must have an erucic acid content of less than 2 percent and also have less than 30 micromoles of glucosinolates per gram of seed. Canadian and U.S. farmers mostly grow low erucic acid and low glucosinolate varieties. High erucic acid oil rapeseed is grown and used for industrial lubricants. This type of rapeseed is mostly grown in Europe, although some production occurs in Canada and the United States.

In January 1985, the U.S. Food and Drug Administration granted canola oil GRAS (Generally Recognized as Safe) status for use in human foods. This has led to greatly increased sales and demand in the United States, with U.S. production meeting only part of the demand. Canola oil has achieved worldwide commodity status and is used extensively in Japan, Canada and Europe.

Canola Varieties

Canola is the genetically altered form of rapeseed, which is comprised of three species: *Brassica napus*, known are Argentine canola; *Brassica rapa*, known as Polish canola; and *Brassica juncea*, known as quality canola brown mustard. All species belong to the Cruciferae (mustard) family. Canola also has been referred to as "double low" rapeseed because the processed oil contains less than 2 percent erucic acid and the meal less than 3 mg/g of glucosinolates. This makes it acceptable as an edible oil and as animal protein feed. Canola oil is considered one of the highest quality edible oils available.

Each canola species has distinct agronomic characteristics that should be considered when selecting a variety to grow. Both spring and winter annual types are available in *B. napus* and *B. rapa*. Winter canola is not grown in North Dakota because of unsatisfactory winter hardiness. The winter canola has not survived in trials in North Dakota, northwestern Minnesota or the prairie provinces of Canada. Nearly all canola raised in North Dakota is spring-sown *B. napus*.

In general, *B. napus* canola has a higher oil content and is higher yielding (>20 percent), later maturing (10 days to three weeks), taller, more disease tolerant and more susceptible to late spring frosts than the *B. rapa* canola. The Polish varieties are most adapted to shorter growing seasons and where soil moisture may be limited. The main advantage of *B. rapa* canola over *B. napus* canola is if planted early, it flowers before the high temperatures of July, which reduces the potential for damage to flowers and related yield losses. If planted late, *B. rapa* canola will be more likely to mature before the first fall frost and produce a crop with fewer green seeds.

Canola varieties are developed from three different breeding techniques and include open-pollinated, synthetic hybrids and hybrids. Hybrids and synthetic hybrids generally have higher yield potentials but also have higher seed cost. *Brassica juncea* canola recently was developed in Canada. In 2002, the first two varieties were released under contract production in Canada. This species is more suitable to hot and dry conditions. *Brassica juncea* pods do not shatter as easily as other canola types and producers will be able to straight combine the crop. *Brassica juncea* canola is approved to grow in the United States.

Herbicide-tolerant canola (HTC) varieties that exhibit resistance to a specific herbicide have been developed. HTC presently available include: Roundup Ready and Liberty-tolerant varieties that have been genetically modified, and Clearfield (Imi) varieties, which are resistant to the herbicide Beyond. Triazine-tolerant canola was developed in the early 1980s but is not used in the state. Clearfield- and triazine-tolerant varieties were developed from traditional breeding techniques and have not been genetically modified.

Markets are available for oils with specific oil characteristics and require a modification of canola's standard fatty acid profile. A small demand also remains for high erucic acid rapeseed (HEAR) that is used in plastics, lubricants, lacquers and detergents. Plant breeders have developed special-use varieties to meet these needs. Special-use varieties should be grown on a contract basis and must remain identity preserved.

Canola is a relatively easy crop to manipulate genetically and many new varieties with new quality and agronomic characteristics will be introduced in the future.

Variety Selection

Choosing a variety is one of the most important decisions a producer makes in raising a successful crop. A variety's performance may differ from year to year and location to location due to changing environmental conditions. When selecting a variety to grow, consider a variety's performance across a number of locations and/or years. Key factors to use in choosing canola varieties are:

- **Yield** — Select varieties with consistently high yields.
- **Maturity** — *Brassica napus* canola varieties can differ in maturity by 10 days or more.
- **Plant Height and Lodging** — These factors are important considerations for ease of swathing.
- **Disease Tolerance** — Grow varieties with good resistance to blackleg. Varieties with superior lodging resistance reduce the incidence of sclerotinia.
- **Seedling Vigor** — Varieties with good seedling vigor will be more competitive with weeds and more likely to push through a shallow crust.

Growth Stages

Understanding the growth and development of a canola plant helps the producer make more effective management decisions. Six main growth stages characterize canola growth. Temperature, moisture, light, nutrition and variety influence the length of each growth stage.

Pre-emergence (Germination)

The germination process involves water absorption, swelling, splitting of the seed coat and emergence of the root tip. An active hypocotyl pushes cotyledons through the soil surface. Germination typically takes from four to 10 days, depending on soil temperature and moisture,

seed soil contact and depth of planting. During this stage, canola is susceptible to many soil-borne pathogens.

Seedling

Once emerged, the cotyledons open and supply the new seedling with nourishment. At this stage, the seedling still is vulnerable to soil pathogens and very susceptible to flea beetle infestation. The growing point of canola is located between the two cotyledons. The exposed growing point makes the canola seedlings more susceptible to spring frosts, soil drifting, insects and hail damage. Canola is a very poor competitor with weeds at this stage, making good stand establishment extremely important.

Rosette

The first true leaves develop four to eight days after emergence. The plant quickly establishes a rosette, with older leaves at the base increasing in size, and smaller, younger leaves developing in the center. During this time, the stem length remains basically unchanged, although its thickness increases. An increase in leaf area index characterizes the rosette stage. Rapid and abundant leaf growth captures more sunlight and produces more food for the plant, thus producing more dry matter per day and increasing yield potential. A rapidly developing canola canopy encourages root growth, reduces soil moisture evaporation and competes with weeds by shading.

Bud

Bud formation is triggered as the days lengthen and temperatures rise. A cluster of flower buds becomes visible at the center of the rosette and the main stem "bolts" or lengthens. Secondary branches arise from buds, which develop in the axils of the upper leaves.

Secondary branches develop one to four leaves and a flower bud cluster. The canola plant reaches its maximum leaf area index in the late bud stage. Leaves are the major source of food and their removal results in large yield losses. The vegetative stages (seedling to first flower) for *B. napus* generally range from 40 to 60 days, depending on environmental conditions.

Flowering

Flowering begins with the opening of the lowest bud on the main stem and continues from 14 to 21 days. Three to five flowers or more open per day and 40 percent to 55 percent of the flowers that open will develop pods. High temperatures coupled with moisture stress can reduce yield potential severely during this stage.

Ripening

Ripening begins when the petal on the last formed flower on the main stem falls. By the time flowering is finished, most of the leaves have yellowed and fallen from the plant. Seed fill is complete approximately 35 to 45 days after flower initiation. The crop is considered ripe and ready to swath when 30 percent to 40 percent of the seeds on the main stem have turned color. Spring *B. napus* usually matures 85 to 110 days after planting, depending on variety and environmental conditions.

Growth-Stage Key

(Source: Harper and Berkenkamp. 1975. Revised growth-stage key for Brassica campestris and B. napus. Can. J. Plant Sci. 55: 657-678.)

Stage Description of Main Raceme

- **0 Pre-emergence**
- **1 Seedling**
- **2 Rosette**
  - 2.1 First true leaf expanded
  - 2.2 Second true leaf expanded
  - 2.3 Continue for each additional leaf
- **3 Bud**
  - 3.1 Flower cluster visible at center of rosette
  - 3.2 Flower cluster raised above level of rosette — 'bolting'
  - 3.3 Lower buds yellowing
- **4 Flower**
  - 4.1 First flower open
  - 4.2 Many flowers open, lower pods elongating
  - 4.3 Lower pods starting to fill
  - 4.4 Flowering complete, seed enlarging in lower pods
- **5 Ripening**
  - 5.1 Seeds in lower pods full size, translucent
  - 5.2 Seeds in lower pods green
  - 5.3 Seeds in lower pods green-brown or green-yellow, mottled
  - 5.4 Seeds in lower pods yellow or brown
  - 5.5 Seeds in all pods brown, plant dead

Field Selection and Preparation

Canola can be grown on most soil types. Canola has similar moisture requirements as those of cereal grains and can be grown on a wide range of soil types. It is best

suited to clay-loam soils that do not crust. If grown on soil with poor internal drainage, good surface drainage is essential, as it cannot tolerate standing water or water-logged soils. In regions of the state where the risk of heat and drought stress is higher, avoid planting on light or sandy soil. Canola is less tolerant of drought than small-grain crops. Canola should not be planted on saline or alkaline soils because it is less tolerant than cereal grains.

Canola can be grown in a no-tillage or conventional tillage cropping system. Avoid excessive tillage in the spring to prevent drying out the seedbed. Canola is very susceptible to soil crusting. The seedbed must be firm for seed, and soil moisture contact is critical for rapid emergence. Producers might consider it as a crop to plant on fallow if soil moisture recharge on recrop land is limited. Seeding canola into dry soil is not recommended.

Planting Guidelines

Canola can be planted with a variety of seeding equipment. Using a drill that is able to seed shallowly is important. The optimum depth to seed canola is 0.5 to 1 inch. Seeding depth should not exceed an inch with small-seeded canola varieties. Large-seeded hybrid varieties can be seeded deeper than 1 inch; however, the depth should not exceed 1.5 inches. Do not broadcast or spread canola seed and harrow it in. In most cases where this has been tried, uneven emergence and poor stands have occurred. Seeding canola where a uniform depth can be obtained is best.

The minimum soil temperature for germination is 38 F. Soil temperature will determine the length of time from planting to emergence. If soil temperatures average in the low 40s after planting, canola will take 17 to 21 days to emerge. If temperatures average in the low 50s, canola will take approximately 10 days to emerge.

Planting Dates

Canola should be planted prior to planting cereal grains. Canola should be planted in April to early May to maximize yield. Planting date research indicates that delayed planting beyond May 1 in the southwestern regions and May 15 across the rest of the state will result in significant yield reductions. In cases of deciding to replant or if planting is delayed due to weather, canola should "not be considered" for planting later than May 15 in the southern and south-western regions of the state, no later than May 25 in the east-central and west-central regions of the state and no later than June 5 in the northern and northeast regions of the state. Canola is very susceptible to heat and drought stress during flowering. Canola seedlings are frost tolerant and can tolerate temperatures as low as 24 F.

Rates and Establishment

Seeding rates will vary with canola, depending on the seed size of the variety. Seeding rates will range from 4 to 8 pounds per acre for Argentine varieties and 3 to 6 pounds for Polish varieties. A common rule of thumb for seeding canola is 5 pounds per acre or 10 acres per 50-pound bag. Seeds per pound vary greatly among canola varieties. Adjusting for these differences is important to avoid a stand being too thick or too thin.

The optimum seeding rate is 600,000 pure live seeds (PLS) per acre; which equates to 16 PLS per square foot. A grower must know the number of seeds per pound of the variety and establish a seeding rate by plant population. As a general rule for the Argentine canola, hybrids will contain 75,000 to 100,000 seeds per pound, whereas open pollinated varieties will contain a range of 135,000 to 160,000 seeds per pound. For the Polish varieties,

seed count usually will be greater than 200,000 seeds per pound.

Seeding rate/plant population research studies indicate that planting 16 PLS per square foot should establish an optimum stand of eight to 14 plants per square foot. Four plants per square foot are considered a minimum stand for canola. However, with herbicide-tolerant canola, stands can be as low as two plants per square foot, providing weeds are controlled and that the plants are uniformly spaced with no large areas where no canola is growing.

Dormant Seeding

Dormant seeding of canola can be defined as seeding canola in cold, nearly frozen soil, which will inhibit germination in the fall. The objective is that the seed remains dormant after planting until early spring. As conditions become favorable in the spring, the canola germinates and emerges earlier than spring-planted canola. Determining when to fall seed is difficult since growers can not use a specific calendar date. The soil needs to be cold, if not frozen (below or near 32 F in the top 2 inches). If soil temperatures warm to 38 F or higher, the seed will germinate and will be killed once the soil freezes.

In the past, growers have found that planting dormant seed canola as the soil temperatures approached freezing, but before the first snow, was difficult. Research results have shown that fall seeding canola is a high-risk practice, especially in growing areas with unstable winter temperatures and soils, which have a potential to dry out significantly during the winter. The greatest challenge has been getting even and well-established stands.

Soil Fertility Requirements

Mineral nutrient requirements for canola

Nitrogen (N), phosphorus (P) and potassium (K) requirements of canola and mustard are similar to those of small grains. Sulfur (S) requirements for canola are higher than most crops. Soil cores should be taken from 0 to 24 inches deep and divided into 0- to 6-inch and 6- to 24-inch samples. P and K should be analyzed on the 0- to 6-inch sample, while N and S should be tested on each depth.

Nitrogen

Nitrogen recommendations are based on the following formula:

NR = (YG X 0.05) - STN - PCC

where NR = supplemental nitrogen recommended

YG = yield goal in lb/A

STN = soil nitrate-N 0 to 24 inches

PCC = previous crop credit if legumes were grown the previous season

Nitrogen recommendations at selected yield goals are shown in **Table 1**. Yield goals should be conservative, based on a five-year average and not on a potential optimistic yield, such as what a wheat grower might do. Ammonium sources of N may be fall-applied on most North Dakota soils, except on sandy loam textures or coarser, or where flooding is expected in the spring. Guidelines for fall N application may be found in the *North Dakota Soil and Fertilizer Handbook* (NDSU EB-65, revised, 2002). Spring application may be made preplanting or at planting. Canola is very sensitive to fertilizer salts. No more than 5 lb/A of N is recommended with the seed in 12-inch row spacing

for medium-textured soils, but the rate can be increased proportionally with narrow row spacing or an increase in seed spread (**Table 2**).

Phosphorus (P) and Potassium (K)

P and K recommendations are shown in Table 1. Canola is a good scavenger of P and a row-starter fertilizer rate of 20-30 lb P_2O_5/A is sufficient for most soil test levels. On light soils where no nitrogen is recommended, 11-52-0 (MAP) would be a better seed-placed choice of phosphate since its nitrogen component is not as likely to injure seed as 18-46-0 (DAP). K, if needed, may be added to row starter if the final N + K_2O is below the maximum allowable rate (Table 2). Broadcast P and K are acceptable. However, a small amount of P as a row starter is recommended in addition to any broadcast.

Sulfur

Canola has a special requirement for sulfur. The consequences of low soil S levels are very serious in canola production. Spectacular yield increases due to sulfur application have been demonstrated in North Dakota (**Table 3**). A composite soil test for sulfur may not represent sulfur fertility variation across the field. The current S soil test tends to overestimate available sulfate-S, and field variability is huge. Growers should consider applying 20 to 30 pounds of S per acre regardless of soil test level. Research in Manitoba and North Dakota suggests canola growers should use a sulfate or thiosulfate form of sulfur. Elemental sulfur forms have not performed well in regional trials.

Micronutrients

There have been no canola yield responses to any micronutrient in North Dakota.

Table 1. N, P and K recommendations for canola.

Yield Goal*	Soil N + supplemental N	Olsen-P, ppm					Soil test K, ppm.				
		VL	L	M	H	VH	VL	L	M	H	VH
		0-3	4-7	8-11	12-15	16+	0-40	41-80	81-120	121-160	160+
lb/A	lb/A at 0-2 ft.	lb P_2O_5/A					lb K_2O/A				
1000	65	35	25	15	0	0	50	35	20	0	0
1500	100	50	35	20	10	0	70	50	30	10	0
2000	130	65	45	30	10	0	95	70	40	15	0
2500	165	80	60	35	15	0	120	85	50	15	0

* Be conservative on yield goals to avoid lodging and low oil content.

Table 2. Maximum rates of seed-placed N + K_2O for canola.

Soil Texture	Disc or knife (1 inch spread) Row Spacing			Spoon or Hoe (2 inch Spread) Row Spacing			Sweep (4-5 inch Spread) Row Spacing		
	6 inch	9 inch	12 inch	6 inch	9 inch	12 inch	6 inch	9 inch	12 inch
	Lbs N + K_2O / Acre								
Light	5	0	0	20	15	10	30	20	15
Medium	10	5	5	25	20	15	35	25	20
Heavy	15	10	5	35	25	20	45	30	25

Table 3. Response of canola to ammonium sulfate and degradable elemental sulfur on three soil types, on conventional till and no-till. Rocklake, N.D.

Rate lb S/acre	Source	Tillage	Soil Types		
			Buse	Barnes	Svea
			Yield, lb/acre		
0		CT	400	1020	1180
20	AS	CT	1810	1980	1860
40	AS	CT	1890	1670	1980
40	ES	CT	1260	1290	1470
0		NT	30	240	1450
20	AS	NT	1650	1680	2100
40	AS	NT	1810	1870	1810
40	ES	NT	620	1060	1630

LSD 5% within tillage treatments 155 lb/acre.

Sources: AS = ammonium sulfate (21-0-0-24S)
ES = degradable elemental sulfur (0-0-90S)
Tillage: CT = conventional tillage; NT= no-till

(Source: Canola response to sulfur fertilizer applications under different tillage and landscape positions. 1996. Annual report to USDA/CSREES/ Special programs, Northern Region Canola Grant and the North Dakota Oilseed Council. E.J. Deibert, S.Halley, R. Utter, and J. Lukach.)

Weed Control in Canola

- A uniform stand of a competitive canola variety is the best weed control tool. Canola is not very competitive early, but becomes more competitive as it approaches the late rosette and bolting stage. The competitive ability of many canola varieties may allow a grower to reduce costs by spraying only once, or in some cases not at all.

- Some weeds are more competitive with canola than others. Canada thistle and wild oats are very competitive early in the growing season. High densities may require a split herbicide application. Research has shown a 400 lb/A yield advantage where wild oats were removed early (three-leaf canola) by PPI and/or POST herbicides, compared with late applications (six-leaf canola).
- NDSU studies have shown that a rotation of wheat followed by canola will reduce Canada thistle densities significantly. Suppress Canada thistle with pre- or postharvest glyphosate in the fall prior to seeding canola. Glyphosate (In RR Canola) and Stinger provide excellent Canada thistle control in canola. Consider a split application if Canada thistle densities are high (>1/ft^2) or emerge before or about the same time as canola.

  Areas heavily infested with Canada thistle can be controlled, but will require at least three years to significantly reduce weed densities. Control measures should start in the wheat crop with a broadleaf herbicide applied in-crop followed by a preharvest or postharvest glyphosate application. Postharvest applications are most effective when adequate weed regrowth has occurred along with warm, moist conditions in mid- to late September. However, preharvest applications usually provide more consistent control because many times postharvest applications are not warranted due to limited weed regrowth. Canola can be very competitive with Canada thistle, and combined with a herbicide program of glyphosate or Stinger, can help reduce weed densities significantly.

- Muster, which was used to control wild mustard, was withdrawn from the market in 2004.
- Most postemergence herbicides used in canola can be tank mixed with labeled pyrethroid insecticides. Be sure to consult the labels of all pesticides before mixing.

Weed Control Options for Canola

The following information provides general details on herbicide cost, rate, weeds controlled, when to apply, etc. This information does not supercede the herbicide label. Always read and follow instructions in the most current label. Herbicide costs listed below do not take into account program incentives that retailers or manufacturers offer. The herbicides listed were registered for use as of the 2004 growing season. Illegal herbicide use could result in condemnation of the crop and possible fines.

Sonalan (ethalfluralin)

$/A: 4.90 to 9.00

Rate: 5.5 to 9.5 lb 10G; 1.5 to 2.5 pt HFP (0.55 to 0.95 lb ai)

Weeds: Controls foxtail, barnyardgrass, several annual broadleaf weeds

Apply: Preplant incorporated

Remarks: Select herbicide rate based on soil type. Sonalan may be applied in the fall or spring. More effective on kochia than Trifluralin. Higher than labeled rates may result in crop injury, especially in prolonged wet or cold soils.

Broadcast application rates:

Soil texture	Sonalan 10G (lb/A)	Sonalan HFP (pt/A)
Coarse	5.5	1.5
Medium	7.5	2
Fine	9.5	2.5

Trifluralin

$/A: 3.25 to 8.50

Rate: 5 to 10 lb 10G; 1 to 2 pt (0.5 to 1 lb ai)

Weeds: Controls foxtail, barnyardgrass, several annual broadleaf weeds

Apply: Preplant incorporated

Remarks: Select herbicide rate based on soil type. Trifluralin may be applied in the fall or spring. See label for incorporation instructions.

Broadcast application rates:

Soil texture	Trifluralin 10G (lb/A)	Trifluralin 4EC (pt/A)
Coarse	5	1
Medium	7.5	1.5
Fine	10	2

Stinger (clopyralid)

$/A: 15.00 to 30.00

Rate: 0.25 to 0.5 pt (0.094 to 0.187 lb ai)

Weeds: Canada thistle, perennial sowthistle, dandelion, curly dock, wild buckwheat, cocklebur, marshelder, prickly lettuce, ragweed, false chamomile, nightshade species and biennial wormwood.

Apply: 2- to 6-leaf canola stage

Remarks: Stinger may be tank mixed with other canola herbicides. For best control of Canada thistle, apply Stinger after the majority of basal leaves have emerged but prior to bud stage. Do not apply within 50 days of harvest.

Liberty (glufosinate) — For Liberty Link Canola Varieties

$/A: 13.35-16.20

Rate: 28-34 fl oz (0.37-0.44 lb ai)

Weeds: Controls most annual broadleaf weeds, small annual grasses

Apply: Cotyledon up to early bolting

Remarks: **Apply postemergence to Liberty Link canola varieties only.** Apply with AMS fertilizer at 3 lb/A. Liberty is a nonresidual, contact herbicide. Must apply to small grasses as Liberty will only suppress large grasses. May tank mix 28 fl oz with a ½ rate of Assure II, Poast, or Select to control annual grasses. The AMS rate may be reduced to 1.5 lb/A when tank mixing Liberty with a grass herbicide. Do not add adjuvants other than AMS. Liberty will not control perennial weeds. See label for optimum application timing to control broadleaves and grasses, which is based on weed size.

Beyond (imazamox)

$/A: 15.95

Rate: 4 fl oz (0.031 lb ai)

Weeds: Controls many annual broadleaf and grass weeds.

Apply: Prior to bloom

Remarks: Apply postemergence on Clearfield varieties only. Apply Beyond with crop oil concentrate (1-2 gal/100 gal) or nonionic surfactant (1 qt/100 gal) and nitrogen fertilizer (2.5 gal/100 gal). Beyond is weak on wild buckwheat and lambsquarters. Beyond will not control ALS-resistant kochia. Beyond will work well in tandem with Treflan or Sonalan to control many annual weeds. Beyond will not control perennial weeds. See label for maximum weed sizes.

Glyphosate — For RR Canola Varieties

$/A: 5.00 (does not include technology fee)

Rate: 0.375 to 0.56 lb ae

Weeds: Most broadleaf and grass weeds

Apply: Emergence to bolting

Remarks: **Apply postemergence on Roundup Ready varieties only.** Apply with AMS fertilizer. Controls most annual and perennial weeds. A sequential application may be more effective on wild buckwheat and Canada thistle. For sequential applications, apply glyphosate to 1- to 3-leaf canola followed by the second application at a minimum of 10 days, but no later than the 6-leaf stage. Allow an 8-week preharvest interval.

Assure II (quizalofop)

$/A: 7.15 to 10.15

Rate: 8 to 10 fl oz (0.88 to 1.1 oz ai)

Weeds: Annual grasses and quackgrass

Apply: Allow a 60-day PHI

Remarks: Controls grasses only. Use higher rates for barnyardgrass and quackgrass. Apply with crop oil concentrate at 1% v/v. Label indicates that barnyardgrass and yellow foxtail control may not be adequate when Assure II is tank mixed with a broadleaf herbicide. For best results, apply Assure II either 24 hours before or 7 days after the broadleaf herbicide.

Rates required for different grass species are:

Barnyardgrass	2-6 inches	8-10 fl oz
Green foxtail	2-4 inches	7-8 fl oz
Yellow foxtail	2-4 inches	7-8 fl oz
Wild oat	2-6 inches	7-8 fl oz
Volunteer cereals	2-6 inches	7-8 fl oz
Quackgrass	6-10 inches	10-12 fl oz

Poast (sethoxydim)

$/A: 6.10 to 12.20

Rate: 0.75 to 1.5 pt (0.14 to 0.28 lb ai)

Weeds: Annual grasses

Apply: Allow a 60-day PHI

Remarks: Poast rate may be lowered to 0.75 pt/A for foxtails and barnyardgrass if these grasses are less than 4 inches. Always apply with one of the following additives: Crop oil concentrate (1 qt), Methylated seed oil (1.5 pt), or Dash HC/Sundance HC (1 pt). Add nitrogen to COC to improve wild oat and volunteer cereal control (2.5 lb AMS or 4 pt UAN solution). Poast is rainfast 1 hour after application.

Rates required for different grass species are:

Barnyardgrass	8 inches (max height)	1 pt
Green foxtail	8 inches	1 pt
Yellow foxtail	8 inches	1 pt
Wild oat	4 inches	1 pt
Volunteer cereals	4 inches	1.5 pt

Select/Prism (clethodim)

$/A: 5.80 to 7.25

Rate: 4 to 6 fl oz (1 to 1.25 oz ai)

Weeds: Annual grasses

Apply: Prior to bolting. Allow a 70-day PHI

Remarks: Do not apply after crop has begun bolting as crop injury may occur. Apply with 1% crop oil concentrate per acre. Do not apply more than 6 fl oz per application to canola.

Rates required for different grass species are:

Barnyardgrass	1 to 4 inches	4 fl oz
Green foxtail	1 to 4 inches	4 fl oz
Yellow foxtail	1 to 4 inches	4 fl oz
Wild oat	1 to 4 inches	5 fl oz
Volunteer cereals	1 to 4 inches	5 fl oz

Relative Herbicide Effectiveness on Weeds and Persistence in Soil

These tables give a general rating for herbicide effectiveness on weeds and herbicide persistence in soil. Under favorable weather conditions, control may be better than indicated. Under unfavorable conditions, some herbicides rated as good may give erratic and unacceptable results. Also, dry and/or cool weather increases herbicide persistence while wet and/or warm weather reduces herbicide persistence.

Weed control ratings in this section are based on the following scale:

E = Excellent = 90 percent to 99 percent control

G = Good = 80 percent to 90 percent control

F = Fair = 65 percent to 80 percent control

P = Poor = 40 percent to 65 percent control

N = None = No control

Herbicide persistence ratings are for residues present 12 months after application:

O = Often S = Seldom N = None

	Barnyardgrass	Field Sandbur	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild oat	Wild proso millet	Herbicide Persistence
Sonalan (PPI)	E	G	E[1]	E	N	G	F	P-F	S
Trifluralin (PPI)	E	G	E[1]	E	N	N	P-F	P-F	S
Stinger	N	N	N	N	N	N	N	N	S
Beyond	E	F-G	E	G-E	F	G-E	E[1]	G-E	N
Glyphosate	E	E	E	E	E	E	G-E	E	N
Liberty	E	G	E	G	P	F-G	G-E	E	N
Assure II	E	E	E	G-E	G-E	E	G-E[1]	E	N
Poast	E	E	E	E	F	E	G-E[1]	E	N
Select/Prism	E	E	E	E	G	E	E	E	N

[1]Herbicides will not control resistant biotypes.

	Buckwheat, Wild	Cocklebur, Common	Flixweed	Kochia	Lambsquarters, Common	Lanceleaf Sage	Mallow, Common	Mallow, Venice	Marshelder	Mustard, Wild	Nightshade, Eastern Black	Nightshade, Hairy	Redroot Pigweed	Prickly Lettuce	Ragweed, Common	Smartweed, Annual	Sunflower	Thistle, Russian	Wormwood, Biennial	Thistle, Canada
Sonalan (PPI)	P-F	P	P	F-G	E	N	-	F-G	N	N	P	P	E	P	P	P	N	G-E	N	N
Trifluralin (PPI)	P-F	N	P	F	G-E	N	-	F-G	N	N	N	N	E	N	P	P	N	G	N	N
Stinger	F-G	E	N	N	P-F	F	P	P	E	N	E	E	P	E	G-E	G-E	G-E	P-F	E	E
Beyond	P	G-E	E	E[1]	F	E	P	P	G-E	E	E	E	E	-	P	G-E	E	G-E	P	N-P
Glyphosate	F-G	E	G-E	F-E	P-E	E	F-G	E	G-E	G-E	F-G	F-G	E	E	E	F-E	G-E	G	G-E	G-E
Liberty	E	E	G-E	E	F-G	E	E	E	E	E	E	E	E	G-E	E	E	E	G-E	E	P
Assure II	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Poast	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Select/Prism	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

PPI = Preplant Incorporated

[1]Herbicides will not control resistant biotypes.

Rotation restrictions for planting canola.

Herbicide	Months after application	Herbicide	Months after application
Accent	18	Hornet/WDG	26b
Accent Gold	26b	Lightning	40b
Ally XP (a)	34c	Lumax (<3 pt/A)	18
Ally Extra (0.2 oz)	22d	Matrix	18
Amber	b	Maverick	b
Assert	12/15e	NorthStar	18
Atrazine (0.38 lb ai)	NCS	Olympus	b
Atrazine (0.38-0.5 lb ai)	2CS	Option	2
Atrazine (0.5-1.0 lb ai)	2CS	Paramount	10
Authority	24	Peak	22
Balance Pro	18	Permit	15
Basis	18	Plateau	48b
Basis Gold	18	Prowl/Pendimax	NCS
Beacon	18	Pursuit	40b
Boundary	18	Pursuit Plus	40b
Buckle	NCS	Python	26b
Callisto	NCS	Raptor/Beyond	18
Celebrity Plus	18	Rave	b
Curtail/M	5	Reflex	18
Degree	2CS	Sencor	12f
Dicamba	4	Silverado	10
Domain	18	Sonalan	0
Distinct	4	Spartan	24
Epic	12	Spirit	18
Everest	9	Steadfast	18
Extreme	40b	Stinger	0
Far-Go	NCS	Surpass	2CS
Finesse	b	Tordon (1.5 oz)	2CS
FirstRate/Amplify	30b	TopNotch	2CS
Flexstar	18	Trifluralin	0
Gangster	b	Valor	12b
Glean	b	WideMatch	4
Harness	2CS		

continued

NCS = Next cropping season after herbicide application
2CS = Second cropping season after herbicide application

a = Do not use on soil with pH greater than 7.9. Barley and oats can be planted six months after Ally XP application west of U.S. Highway 83.

b = Bioassay. Do not plant until field bioassay indicates it is safe. Accent Gold, Python and Hornet/WDG require a 26-month rotation and a successful field bioassay.

c = Requires soil pH of 7.9 or less, and a 34-month minimum rotation interval and 28 inches of cumulative precipitation.

d = For 0.2 oz/A, requires soil pH of 7.9 or less, 22 months and at least 18 inches of cumulative precipitation. See label for restrictions when using higher rates.

e = Clearfield canola varieties may be planted the season after application. Conventional canola varieties may be planted the following season after application of 1 pt/A in the North Dakota counties of Cavalier, Pembina, Ramsey, Rolette, Towner and Walsh and the Minnesota counties of Kittson, Marshall, Pennington, Red Lake and Roseau.

f = Must add two months if soil pH is 7.5 or above.

Minimum interval between application and rain for maximum postemergence weed control in canola.

Herbicide	Time Interval
Assure II	1 hr
Beyond	1 hr
Glyphosate (Full adj.)	1 hr
Glyphosate (Part. adj.)	4 hr
Glyphosate (No adj.)	4-6 hr
Liberty	4 hr
Poast	1 hr
Select/Prism	1 hr
Stinger	6 hr

Note: Adj. is abbreviation for Adjuvant.

Controlling Volunteer Canola in Succeeding Crops

Canola can volunteer for several years following a canola crop. These volunteers will compete with the succeeding crop and may affect yield, depending on the volunteer density. Take steps during the swathing and combining operations to minimize canola seed losses. Following canola harvest, seeds that remain on or near the soil surface may germinate in the fall and be killed by frost. Avoid deep tillage that will deposit canola seeds several inches deep into the soil, where they are less likely to germinate, and where secondary dormancy is more likely to be induced. If possible, allow time in the spring for canola volunteers to germinate before a tillage operation and then seed the new crop as soon as possible following the tillage operation.

For no-till small grains, consider adding a labeled herbicide to the glyphosate burndown application to control emerged glyphosate-resistant canola volunteers. Canola volunteers that emerge before or with the crop may be very large by the time the postemergence herbicide application is made. Canola volunteers become much more difficult to control with herbicides once they reach the six-leaf to bolting stage. There are some herbicides that provide excellent control of small volunteers, but provide poor control of bolting canola. Canola volunteers will be controlled best when herbicide is applied by the five-leaf stage.

The following tables provide a general rating for herbicide effectiveness on volunteer canola. These ratings were based on research where herbicides were applied either preemergence or at the three- or six-leaf canola stage. All postemergence herbicides were applied with recommended adjuvants. These ratings are based on one and sometimes two years of research. However, these

studies were conducted by planting canola on top of crops to simulate a volunteer situation. The canola seed used was Helix-treated to prevent flea beetles from destroying the volunteers so that herbicide effectiveness could be evaluated independently of flea beetle activity and soil-borne diseases. In the real-world situation, flea beetles and diseases actually may help control volunteer canola because the seed is untreated. Volunteer canola control will improve where densities are lower and canola is smaller.

Volunteer canola control ratings in this section are based on the following scale:

E = Excellent = 90 percent to 99 percent control

G = Good = 80 percent to 90 percent control

F = Fair = 65 percent to 80 percent control

P = Poor = 40 percent to 65 percent control

VP = Very poor = Less than 40 percent control

N = None = No control

Herbicide costs are approximate retail prices for small quantities in 2004. The prices do not include adjuvants or application costs. Prices will vary, depending on location, wholesaler, bulk discounts, seasonal changes and company incentive programs. Prices are averages based on a statewide dealer survey for small quantities. Producers should consult local agricultural suppliers for exact prices in their area.

Volunteer canola control in CORN.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Accent	0.5 oz	16.00	—	E	E
Atrazine	0.5 pt	0.65	—	VP	VP
Balance Pro	3 fl oz	19.50	E	—	—
Callisto	3 fl oz	12.00	—	E	G
2,4-D amine	0.5 pt	0.80	—	G	P
Distinct	4 oz	10.00	—	G	F
Option	1.5 oz	15.00	—	E	E
Starane	0.5 pt	5.30	—	VP	VP
Steadfast	0.75 oz	15.00	—	E	E

Volunteer canola control in SOYBEAN.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Basagran	0.5 pt	4.90	—	G-E	F
Cobra	6 fl oz	6.60	—	G-E	VP
Extreme	1.5 pt	6.00	E	—	—
Flexstar	0.75 pt	9.00	—	E	E
Harmony GT	0.083 oz	0.95	—	P-F	P
Python	1 oz	9.00	F-G	—	—
Raptor	4 fl oz	15.95	—	E	G-E
Sencor	0.25 lb	4.90	G-E	—	—
Ultra Blazer	0.75 pt	6.75	—	F-G	P
Valor	2.5 oz	9.40	E	—	—

Volunteer canola control in DRY PEA.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Basagran	0.5 pt	4.90	—	G-E	F
MCPA amine	0.5 pt	0.95	—	G-E	P
Pursuit	0.72 oz	7.75	G-E	G-E	G

continued

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Raptor	4 fl oz	15.95	—	E	G-E
Sencor	0.25 lb	4.90	—	G-E	F
Sencor	0.375 lb	7.35	E	—	—
Spartan	4 oz	10.00	P-F	—	—

Volunteer canola control in SUNFLOWER.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Assert	0.8 pt	8.55	—	E	G
Spartan	4 oz	10.00	P-F	—	—

Volunteer canola control in FLAX.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Bronate Adv	0.8 pt	5.60	—	E	F-G
MCPA ester	0.5 pt	1.00	—	E	F-G
Spartan	4 oz	10.00	P-F	—	—

Volunteer canola control in WHEAT.

Herbicide	Rate	Cost	Preemer-gence	3-leaf canola	6-leaf canola
	product/A	$/A	Control rating		
Aim	0.5 oz	2.50	—	VP	VP
Bronate Adv	0.8 pt	5.60	—	E	F-G
2,4-D ester	0.5 pt	0.75	—	G-E	P-G
Dicamba	2 fl oz	1.30	—	P	VP
Express	0.167 oz	2.90	—	E	G-E
Harmony GT	0.3 oz	3.30	—	F-E	P-F
MCPA ester	0.5 pt	1.00	—	G-E	F-G
Starane	0.5 pt	5.30	—	VP	VP

Insect Management and Control

Canola Crop Stage and Insect Pest Scouting Calendar

Seedling to rosette	Rosette to Flowering	Flowering to Pod development	Pod development to harvest
May	**June**	**July**	**August**
Cutworms Diamondback moths Flea beetles Grasshoppers	Cutworms Diamondback moths Grasshoppers Lygus bugs	Aphids Bertha armyworms Blister beetles Diamondback moths Grasshoppers Lygus bugs	Bertha armyworms Flea beetles Grasshoppers Lygus bugs

CRUCIFER FLEA BEETLES *(Phyllotreta cruciferae)*

COLEOPTERA: CHRYSOMELIDAE

The crucifer flea beetle has a single generation per year. The striped flea beetle, *P. striolata*, also feeds on canola in the canola production areas of North Dakota. However, it makes up less than 5 percent of the total flea beetle population. Adult flea beetles overwinter in the shelterbelts and leaf litter near last year's canola fields. Adults start to emerge in the spring as the temperatures warm up to 58 F. Depending on the temperatures, populations will emerge during a longer period of time with cool temperatures or during a shorter period of time with warm temperatures.

The tiny, black colored flea beetles with a metallic bluish sheen move into the canola fields just as the seedlings are emerging. Adults feed on the cotyledons and first true

leaves of seedlings, causing pitting and holes in the leaves. Damage is most serious to seedling plants and can cause seedling death and significant stand loss. Eggs are laid in the soil and hatch in 12 days into larvae that feed on the root hairs of the canola plant. The larvae feed for three to four weeks, pupate for one week, and then emerge as the new generation of adult flea beetles in mid-July to early August. These beetles feed on maturing crops by chewing on the epidermis of green pods, stems and leaves for several weeks.

Fortunately, populations of summer flea beetles usually are not high enough to cause serious damage. However, extremely high populations feeding on green pods can cause pod shattering and seeds to remain green. After feeding, the adult beetles move into shelterbelts and other grassy overwintering sites. Large numbers of summer populations often indicate that flea beetle pressures may be high next spring.

Pest Management

Currently, the most effective control measure is the use of insecticides. The seedling stage is the critical period, and insecticides need to be applied as a seed treatment prior to planting or a foliar application to protect the crop from flea beetle damage. If growers use treated canola seed, the seedlings should be protected from flea beetle feeding for most of the susceptible seedling stage. Seed treatments usually provide at least three weeks of protection or two weeks after canola emergence in the field.

Adult flea beetles are active and continually emerge for a three- to four-week period in the spring. As a result, field monitoring is critical for any untreated or partially protected fields or areas with a history of heavy flea beetle populations. Growers should watch seedling fields for flea beetle attack on a daily basis. Check several locations in the field (e.g., edges and center). Hot, sunny

weather increases feeding activity and movement; while cool, damp weather slows feeding and favors crop growth. In some instances, flea beetles can move quickly and infest large fields by flying; in other instances beetles invade slowly and walk from plant to plant in a field. Yellow sticky traps can be used as monitoring tools to indicate when and how many flea beetles are moving into fields.

If the seed treatment did not provide adequate protection or was not used, an application of a foliar insecticide may be necessary. **Use foliar applications when 25 percent DEFOLIATION OCCURS ON THE COTYLEDONS AND TRUE LEAVES (Economic Threshold Level).** When flea beetle populations are high, more than one application may be required due to the short residual of insecticides labeled for flea beetle control in North Dakota and the threat of re-infestation from surrounding areas.

Foliar applications must be applied quickly for effective control. One of the problems growers face is being able to cover large numbers of acres quickly when feeding pressure is high. Canola usually can compensate for flea beetle feeding injury once it reaches the four to six true leaf stage.

OCCASIONAL INSECT PESTS: DIAMONDBACK MOTH *(Plutella xylostella)*

LEPIDOPTERA: PLUTELLIDAE

The migrating diamondback moth usually arrives in late May or early June in North Dakota. Its life cycle takes about 32 days to complete from egg to adult. Several generations develop during a single growing season, so all different life stages (eggs, larvae, pupae, adults)

can be found in the field at the same time. The adult is small, about ½ inch long, drab brown in color, and at rest, the forewings of the male moth form three diamonds — hence the name diamondback.

Females lay up to 160 eggs during the night. Eggs hatch in five to six days into pale yellowish-green caterpillars with a forked posterior end. The newly emerged larvae burrow into the leaf and mine the leaf for several days to a week. Then the larvae exit the leaf and feed externally for another seven to 14 days. When disturbed, the larvae thrash backward violently and often drop from the plant on a strand of silk. The larvae pupate for five to 15 days in a white netlike cocoon attached to the leaves, stems or pods.

Larvae feed on the leaves, buds, flowers, seed pods, green outer layer of the stems and occasionally the developing seeds. The amount of damage will depend on the crop stage and the larva densities and size. Extensive feeding on the flowers will delay plant maturity, cause the crop to develop unevenly and significantly reduce seed yield. As leaves wilt and drop in late July to early August, the larvae will feed on the stem, pods and developing seeds. Damaged seeds will not fill completely and may shatter. Severely damaged pods appear whitish in contrast to the normal yellowing and browning of ripening pods.

Pest Management

Sex pheromone traps are useful tools for detecting the flights of the adult diamondback moth. The recommended trap design is the wing trap or delta traps with sticky inserts used to catch the moths. Traps should be suspended near the crop at the field's edge. Traps provide an early indication of a possible infestation. **Two to three generations usually develop in North Dakota. The second generation is the most**

important because it usually is present when the crop is susceptible to damage — blooming to early podding. The third generation usually is too late to damage most crops except for the very late planted fields.

If high numbers of adults (>100 moths per trap per week) are being captured in the traps during bloom to early pod development, monitor fields for larvae of diamondback moth by beating plants to dislodge the larvae from plants. After beating plants, count the larvae on the ground or dangling from plants on a silk thread. Again, check several locations per field.

The action threshold for canola at the pod stage is about 20 per square foot (two to three larvae per plant). No threshold has been established for the early flowering stage; however, insecticide applications likely are required at larval densities of 10 to 15 larvae per square foot (one to two larvae per plant). Early monitoring of adults and larvae, and judicious use of insecticides only when fields are above thresholds, are the best pest management practices for preventing losses from diamondback moth on canola.

A number of natural factors also can affect diamondback moth populations negatively. For example, heavy rainfalls can drown many larvae of the first generation. Humid conditions associated with rainfall also can favor the development of fatal fungal diseases such as *Entomophthorales*. In addition, several parasitic wasps and predators (flies, lacewings, minute pirate bugs, spiders and birds) prey on the larvae of diamondback moth.

BERTHA ARMYWORM
(Mamestra configurata)

LEPIDOPTERA: NOCTUIDAE

The adult moth is about 1½ inches and mainly gray-black with a silvery-whitish kidney-shaped spot and silvery-whitish fringe on each forewing. Moths emerge from the overwintering pupae in mid- to late June and emergence continues through early August. These night fliers are particularly attracted to blooming canola fields for their nectar and egg-laying sites.

Eggs are laid on the lower side of leaves in clusters of 50 to 500 eggs in a typical honeycomb pattern, and hatch in about one week. The emerging larvae (1/10th of an inch) are usually green in color. Mature larvae are about 1½ inches long and vary in color from green and brown to velvety black. Larvae often hide underneath leaf litter and clumps of soil during the day, which makes them difficult to see. Larvae develop for six weeks and then drop to the ground in mid- to late August to pupate. If the autumn is unusually warm, some adult moths may emerge from the puparium only to perish when winter arrives.

As the canola plant drops its leaves, the mature larvae (>½ inch) begin to feed directly on the pods, which causes economically important yield losses and premature shattering. Mature larvae feeding also accounts for 80 percent to 90 percent of the plant material consumed during a larvae's life. Mature larvae even will continue to feed on pods in the swath. Fortunately, populations are kept low during most years because of natural environmental factors such as harsh winters and a number of biological control agents (diseases and parasites).

Pest Management:
Monitoring and Economic Thresholds — Knowing When to Control

Sex pheromone traps can be used to detect bertha armyworms in a general area. The recommended trap design is the green unitrap or bucket trap suspended above the crop canopy near the field's edge. High trap catches generally indicate the level of larval populations to follow. **Fields should be monitored about two weeks after the peak trap catch and scouted regularly to minimize crop losses. Check several locations per field, and continue scouting until an economic threshold is reached or the crop is swathed. The economic threshold is 18 to 22 larvae per square yard. The key to controlling bertha armyworm is:**

- Early detection of adult moths for their presence or absence and relative abundance in an area
- Monitoring fields for young larvae about ½ inch long
- Determining if fields are above economic thresholds
- Fields above the economic threshold level ideally should be sprayed once the hatch is complete and just before larvae move to the pods to feed. Apply a well-timed insecticide in early morning or late evening when larvae are feeding actively.
- Using high volumes of water with insecticide for good coverage of the dense canola canopy

LYGUS BUGS *(Lygus species)*

HEMIPTERA: MIRIDAE

Lygus bugs are comprised of several species belonging to the genus Lygus. The tarnished plant bug, *Lygus lineolaris*, is one of the more common species and is known to feed on more than 200 host plants. Adult Lygus bugs are about ¼ inch in length and pale green, light brown or dark brown with a distinctive triangular marking on their back.

Lygus bugs overwinter as adults in weedy areas and move into canola fields throughout the season. Adults lay eggs in the stems, leaves and flowers of host plants and then die. Immature nymphs hatch from these eggs. These nymphs are small, green, and sometimes confused with aphids. However, Lygus nymphs are very active and move rapidly when disturbed, while aphids do not.

Several generations occur each year, with the second generation developing in late July to early August. Hot, dry weather favors the buildup of Lygus populations and increases the risk of damage to the canola crop. Both immature and adult Lygus bugs feed on growing points, buds, flowers and green pods. Lygus bugs inject a toxic saliva with their piercing, sucking mouth parts during feeding, causing blasting of flowers or buds and shriveled seeds. Blasted flowers turn white within 24 hours and quickly fall to the ground. The small or damaged seeds are lost during harvest. In severe outbreaks in Canada, yield losses from bud blasting and damage to seed have been estimated at 20 percent.

Pest Management

Scout for Lygus bugs just prior to bud formation until seeds within the pod have become firm. Lygus populations can increase suddenly. For example, when an alfalfa (preferred host) field is cut, Lygus will migrate quickly into nearby canola fields and often in high numbers. Use a 15-inch sweep net and make 10 180-degree sweeps at several sampling sites. The economic thresholds developed in Canada are: 15 Lygus per 10 sweeps during bud stage through petal fall, and 20 Lygus per 10 sweeps after petal fall. If soil moisture is good, canola plants usually can compensate for Lygus bug feeding to plants in the bud and flowering stages. However, if populations are high, control during the early pod ripening stage usually is the most economical.

CUTWORMS

LEPIDOPTERA:NOCTUIDAE

Several species of cutworms cause problems to agricultural crops in the northern prairies. Those species include dingy cutworm, red-backed cutworm and pale western cutworm. Adult cutworms are a moth and have dark wing colors (brown to gray) with markings, and about 1½ inch long wing length. Cutworms have one generation a year. They overwinter as eggs or young larvae in the soil. The eggs are laid the previous fall. Eggs hatch in April or early May, and young larvae (or caterpillars) feed at night on weeds and volunteer plants before the canola crop emerges.

Larvae molt six times and grow larger with each instar. A mature cutworm larva is about 1¼ inches long and the size of a pencil in width. Cutworms are most noticeable in canola during late May through the first three weeks of June. After cutworms complete their development in late June, they burrow deeper into the soil and make a small pupal chamber. An adult moth emerges from the pupae in August to early September. These adults mate and lay eggs on or just below the surface of loose, dry soil, weedy stubble or fallow fields, depending on the species' preference.

Cutworm damage first appears on hilltops, south-facing slopes or in areas of light soil, which warm up earlier in the spring. Larvae will cut young canola plants in the seedling to rosette stages. Cut plants can be found drying up and lying on the soil surface. As damage continues, fields will have areas of bare soil where the canola has disappeared. In a severe infestation, the entire field can be destroyed.

Pest Management

Scout fields by looking for freshly damaged (cut off) plants, dig 2 or more inches down around the cut off plant, and search for cutworm larvae. When disturbed, cutworms curl up. Canola is more susceptible to cutworm damage than small grains because cut plants do not grow back (grains compensate by tillering). Three to four cutworms per square yard or a 25 percent stand reduction justifies an insecticide treatment. Cutworm larvae feed actively at night, so an evening application is best. As a cultural control technique, weed-free fields and crusted summer fallow fields are less attractive to egg-laying adults in late summer.

GRASSHOPPERS

ORTHOPTERA: ACRIDIDAE

Grasshoppers are generalists and feed on a wide range of agricultural crops, such as small grains, flax and sunflowers, to name a few. Grasshoppers overwinter as eggs and nymphs start to emerge in late April to early May, with the peak egg hatch in mid-June. Nymphs (young grasshoppers) will go through five molts before transforming into an adult. The length of time from egg to adult is 40 to 60 days. Adults of crop damaging species become numerous in mid-July, with egg laying usually beginning in late July and continuing into the fall. Eggs are deposited in a variety of noncrop areas, including ditches, shelterbelts and weedy fall fields. Both the adults and nymphs feed on green plant material with their chewing mouth parts, creating holes on leaves or pods.

Pest Management

Grasshopper outbreaks usually coincide with several years of low rainfall and drought periods. Cool, wet weather increases the disease occurrence and delays development of grasshoppers. Scout canola in the

seedling stage for the symptoms of nymph feeding and in the pod development stage for adult feeding. Grasshopper damage often is concentrated on field edges and only the field edges will need to be sprayed. Grasshopper thresholds are based on the number of grasshoppers per square yard. Four 180-degree sweeps with a 15-inch sweep net equal 1 square yard. The infestation ratings are listed below in the table. A "threatening" rating would indicate a need to treat with an insecticide.

	Nymphs (young hoppers) per square yard		Adults per square yard	
Rating	**Margin**	**Field**	**Margin**	**Field**
Light	25-35	15-23	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120	80+	28+

BLISTER BEETLES

COLEOPTERA: MELOIDAE

Several species of blister beetle feed on canola, including *Lytta nuttalli*, a large purplish-green beetle; *Epicauta fabricii*, or the ash-gray blister beetle; and *Epicauta ferruginea*, a smaller rusty colored, pubescent beetle. Most species of blister beetle have one generation a year. Adults become active in early to midsummer and lay eggs in the soil. Eggs hatch in about two weeks into a larvae called triungulins, which actively prey on grasshopper egg pods (genus Epicauta) and bee eggs, larvae and stored food (genus Lytta). Larvae overwinter.

Adult blister beetles are attracted to blooming canola fields, where they are ravenous feeders devouring leaves, stems, flowers and pods. These beetles are mobile and often congregate in certain spots in a field because of their gregarious behavior. In some instances, blister beetles feed for a short period of time and then migrate to other plants or fields.

Pest Management

The presence of large numbers of blister beetles in spots of a canola field often has concerned growers. However, adult feeding generally is not significant enough to warrant an insecticide treatment. The "High Plains Integrated Pest Management Guide" recommends treatment when 10 adult blister beetles per plant are feeding on the flowers or pods. However, no economic threshold is set in North Dakota. Use spot treatment with foliar insecticides registered in North Dakota when necessary. These insecticides will control blister beetles. Follow safe pesticide practices when spraying flowering canola to protect honey bees.

APHIDS (CABBAGE APHIDS, TURNIP APHID AND GREEN PEACH APHID)

HOMOPTERA: APHIDIDAE

Several species of aphids (cabbage aphid, turnip aphid, green peach aphid) infest canola and other plants in the mustard family. Individual aphids are small, approximately 2 mm in length, with a pair of tubelike structures called cornicles protruding from the back. Aphids on canola usually are pale green to grayish green and found in large numbers near the top of individual plants. Infested plants often appear shiny from the honeydew they secrete.

Most aphids migrate into North Dakota from the Southern states, and some may overwinter here. Aphids arrive in canola during the late spring. As a result, later planted canola may be more susceptible to heavy aphid infestations.

Females reproduce asexually and within seven days give birth to live young. As aphid populations build up and become crowded, winged adults are produced and disperse to begin new colonies. Multiple, overlapping generations of aphids occur within a season. Aphids suck on the plant's sap and inhibit terminal growth, stunting plant size and reducing seed yield. Aphid infestations often are localized within a field, and usually cause little damage if the infestations occur after pod development.

Pest Management

No thresholds have been established for aphids on canola. In most cases, spraying is not economical because aphids are on the top 2 to 3 inches of the plant, where pods are the smallest and contribute little to the overall yield. However, controls may be justified when at least 20 percent of the stems are infested with a cluster of aphids in late flowering or early pod stages.

Scout field edges in upwind areas where aphids tend to be abundant. Note the presence of natural enemies as well as aphids. A treatment may be necessary if the following conditions are met: 1) canola was planted late; 2) plants still are in pod development; and 3) natural enemies such as ladybird beetle adults and larvae, syrphid fly larvae or lacewing larvae are low. Follow safe pesticide practices when spraying flowering canola to protect honey bees.

Insecticides registered for insect control in canola in North Dakota.

Insecticide	Dosage in Lb AI/Acre	Product per Acre	Restrictions on Use
Capture 2 EC *(RUP)*	0.033 - 0.04	1.3 - 2.6 fl oz	For flea beetles, reduced rate is issued as a state 2 (ee) label. Apply in a minimum of 2 gals. of finished spray per acre by air or in a minimum of 10 gals. per acre by ground. When applying by air, 1 to 2 quarts of emulsified oil may be substituted for 1 to 2 qts of water in the finished spray. Do not apply within 35 days of harvest.
Clothianidin			
Poncho		3.84 - 10.23 fl oz per 100 lbs of seed	For use in commercial seed treaters only. Not for use in hopper-box, slurry-box or other seed treatment applications at, or immediately before planting. Provides protection from flea beetles feeding injury. Rate can be varied depending on assessment of flea beetle risk based on population size observed.
Prosper (fungicide premix)		19.2 - 25.6 fl oz per 100 lbs of seed	

RUP = Restricted used pesticides

continued

Insecticide	Dosage in Lb AI/Acre	Product per Acre	Restrictions on Use
Decis 1.5 EC *(RUP)*	0.009	0.8 fl oz	Do not apply more than 1.5 fl oz/acre (0.018 lb ai/acre) in one growing season. Allow 7 days between applications. Do not apply within 7 days of harvest. When applying by air, use a minimum of 2 gals water/acre. For ground applications, use a minimum of 5 gals water/acre.
Gaucho 600 (Imidacloprid)		10.24 - 25.6 fl oz per hundredweight of seed	Primarily for use in commercial seed treaters. Canola seed may be treated as an end-use seed treatment on agricultural establishments at, or immediately before planting, using a liquid or slurry treatment device. Provides protection from flea beetle feeding injury. Rates can be varied depending on assessment of flea beetle risk based on population size observed.

Insecticide	Dosage in Lb AI/Acre	Product per Acre	Restrictions on Use
thiamethoxam Helix (10.3 % active) Helix Xtra (20.7% active)		23 fl oz per hundredweight of seed	For use in commercial seed treaters only. The formulations vary by the concentration of insecticide. Provides protection from flea beetles feeding injury. Helix contains 3 fungicides to protect against seed-borne blackleg, seed-borne Alternaria, and the seedling disease complex. There is a 30-day plant-back restriction.
Methyl parathion 4EC *(RUP)*	0.5 lb/acre	1 pt	Apply using a minimum of 3 GPA. Do not apply within 25 days of harvest. Do not enter treated fields within 48 hours after application. Fields must be posted.
Proaxis *(RUP)*	0.0075 - 0.015	1.92 - 3.84 fl oz	Do not apply within 7 days of harvest. When applying by air, apply in a minimum of 2 gals water/acre.
Warrior *(RUP)*	0.015 - 0.03	1.92 - 3.84 fl oz	Do not apply within 7 days of harvest. When applying by air, use a minimum of 2 gals water/acre.

RUP = Restricted used pesticides

Disease Management and Control

Blackleg

Appearance

Blackleg, *Leptosphaeria maculans*, may occur as a mild strain or low-virulence strain, or as one of the virulent or aggressive strains. Infections from the mild strain usually occur late in the season. They do not girdle the stem and produce only a few tiny black fruiting bodies called pycnidia.

The virulent or aggressive strains may infect early, causing leaf spots any time from the seedling stage to crop maturity. The leaf spots are a tan or buff color and round to irregular in shape; by summer the leaf spots are filled with many tiny black pycnidia.

Stem lesions that the virulent strains produce are gray and dark bordered, later turning dark gray to black. Stem lesions may occur anywhere, but often are at the stem base where a leaf was attached. The lesions become sunken and may girdle the stem. Plants may lodge because of stem breakage at the soil line. Early infection causes premature dying of the plant and also may result in lodging. Pycnidia form in the stem lesions. Late infection may result in unthrifty or dying plants with few above-ground symptoms. When infected roots are sliced open with a knife, they will be black, gray or streaked with gray. The interior of healthy roots will be cream colored.

Pods and seeds also may be infected. Infected pods split open, resulting in seed loss. Seed produced in infected pods may be shriveled and gray in color.

Survival and Spread

The blackleg fungus survives for several years on infected crop residue and also is seed borne. The highest percent of infected plants usually comes from airborne

sexual spores called ascospores that are discharged from fruiting bodies on previous canola crop residue. Maximum ascospore discharge occurs in the second year following crop growth. Little disease spread occurs more than one to three miles from infected crop residue.

Following infections from ascospores, masses of tiny black pycnidia form in the resulting leaf and stem lesions. During wet weather, these pycnidia release masses of pink spores that splashing rain spreads. The pycnidia-produced spores are responsible for localized spread of the blackleg fungus, resulting in infection foci.

Research in Canada has shown that early infections cause the greatest damage, with infections before the six-leaf stage causing severe yield loss in susceptible varieties. In fact, stems are most susceptible to infection when the plant is in the cotyledon or one- to two-leaf stage. Some of the less susceptible varieties have a longer period of latent infection, i.e., the period from infection to symptom expression. This may help minimize injury.

Temperatures in the 70s and extended periods of plant canopy wetness favor infection. Temperatures of 86 F or higher, or temperatures around 50 F or lower, inhibit disease development. Plant injury from insects, hail or herbicides increases incidence and severity of blackleg.

Disease Management

Do not introduce blackleg into new canola production areas. In areas where blackleg already is established, canola crop residue is the primary source of inoculum. Management of crop residue and crop rotation are essential to blackleg control in these areas.

Avoid planting in or next to severely infested fields. This is especially important in the first and second years following a canola crop. The airborne ascospores may blow in from distances of one to three miles, and rarely

up to five miles. Keep records on crop rotations and cooperate with your neighbors to avoid planting near a field that recently was planted to canola. Use a four-year crop rotation with susceptible canola.

Both wild mustard and volunteer canola are hosts to blackleg and should be controlled in crops rotated with canola.

Use moldboard plowing or other deep tillage to bury canola residue. Chisel plow in the next two seasons to avoid bringing canola residue back to the soil surface. This speeds the decomposition of canola residue and prevents the release of ascospores. Decomposition of crop residue is more rapid in wet years than in dry ones.

Use disease-free seed. This especially is important when planting in new areas. Treat seed with Helix Lite, Helix Xtra or Prosper 400. These treatments are highly effective against seed-borne blackleg, and especially are important for seed being planted in new areas. Control of seed-borne blackleg between Helix Lite and Helix Xtra is the same, but the Helix Xtra contains more thiamethoxam insecticide and provides longer early season control of flea beetles. When planting in new areas, use treated seed even if the seed was tested for blackleg and found to be free of it. Treatment lessens the danger of inadvertently introducing blackleg into new areas.

Use disease-resistant varieties. Many Argentine *(B. napus)* canola varieties available have moderate to good blackleg resistance. Use varieties that have at least a moderately resistant or preferably a resistant reaction. Consult the current year's canola variety trials (NDSU Extension Service publication A-1124) for information on the blackleg reaction of canola varieties.

Plant certified blackleg-free, fungicide-treated seed of a variety that has a resistant blackleg reaction rating.

Quadris is registered in the United States for early season application to control blackleg. The economics of its use haven't been determined.

Sclerotinia Stem Rot

Sclerotinia stem rot has been the most serious disease of canola in North Dakota and Minnesota in recent years, with statewide incidence (percent of infected plants) as high as 19 percent in North Dakota in 1993 and 19 percent in Minnesota in 1997. Estimated losses from *Sclerotinia* were as high as 13 percent in North Dakota in 1993 and 13 percent in Minnesota in 1997, with estimated losses in severely infected fields approaching 50 percent.

Appearance

Infections begin near the end of flowering, first developing around the cast petals. A targetlike pattern of light brown, mushy tissues develops. Lesions spread down infected leaf petioles or branches to main stems. Infected areas become bleached or white and the tissues become shredded. If the main stem is infected, plants may die early, reducing seed production, and plants may lodge. Lodging usually occurs when shredded stems bend at 6 to 18 inches above the soil. Hard, black bodies that resemble rat droppings may be produced in infected stems. These are known as *sclerotia*. They are not produced in every infected stem, but can be helpful in identifying Sclerotinia stem rot.

Survival and Spread

The Sclerotinia fungus, *Sclerotinia sclerotiorum*, produces sclerotia in the stems. Although not many sclerotia are produced per stem, the total production of sclerotia per

acre may be quite high, up to 40 or 50 pounds. Sclerotia fall to the soil at harvest and survive on or in the soil for several years.

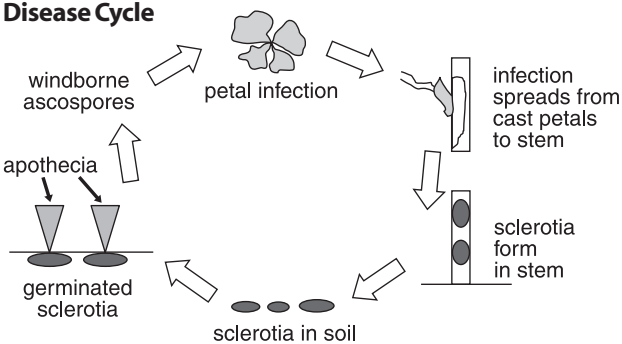
If the soil is at or near field capacity for 10 to 14 days, the sclerotia may germinate to form tiny mushroomlike fruiting bodies that resemble miniature golf tees. These fruiting bodies, called apothecia, produce millions of airborne spores. The spores can be produced not only in canola fields, but also in fields of other crops, including small grains. The spores escape from the canopy and the wind may carry them to nearby fields.

The spores do not infect healthy green plant tissue, but need a food source. As canola petals die and fall onto lower portions of the plant, spores on the petals may germinate and begin to grow, especially if the canopy stays wet for long periods of time. Once growth is established on the cast petals, infection proceeds into the surrounding tissues.

Role of Environment

Wet weather preceding flowering and at flowering favors disease development. At least 1 to 2 inches of rain are required before flowering to saturate the surface soil and stimulate formation of apothecia. The foliage in the canopy must be wet for the better part of two days for the petals to be colonized and infection to occur. Infections in canola may continue to spread as long as the canopy remains wet for many hours. Sclerotinia development may cease in hot or dry weather, but it can resume once cooler and wet weather resumes. Temperatures in the 70s are more favorable than higher temperatures. Disease development ceases at 86 F, or possibly even as low as 81 F.

Sclerotinia Disease Cycle



Survival

The pathogen survives as sclerotia in or on the soil for several years; some sclerotia may survive as long as four to six years. Each year some sclerotia die. They may die because of freezing and thawing or wetting and drying, especially if they are on or near the soil surface. Various soil microorganisms may colonize and kill them. The top layer of soil has the most microbial activity.

Hosts

Many broad-leaved plants are hosts of *Sclerotinia*. Sunflowers, dry beans, canola, crambe and soybeans are some of the most susceptible hosts and are likely to support the greatest production of sclerotia. Chickpeas and lentils also are quite susceptible but support less production of sclerotia. Field peas and flax are much less susceptible and produce few (peas) or no (flax) sclerotia. Many broad-leaved weeds, including lambsquarters, Canada thistle, ragweed and marshelder, also are susceptible. Members of the grass family, including small grains and corn, are immune.

Disease Management

Crop rotation is important, but the sclerotia survive for long periods in the soil and the spores may blow into canola fields from nearby fields. Large concentrations of susceptible crops and several years of wet weather at flowering can contribute to a buildup of Sclerotinia in an area. Try to avoid more than one highly susceptible crop, such as canola, crambe, sunflowers, dry beans or soybeans, in a rotation. Semi-leafless peas support less buildup of Sclerotinia than do the vining types, and may be acceptable in a rotation with canola. Flax and buckwheat have low susceptibility. In irrigated trials at Carrington, N.D., (Schatz, unpublished), no sclerotia were produced in flax, so flax appears to be a relatively safe crop in rotations with canola.

Tillage: Some studies indicate that sclerotia near the soil surface break down faster than those buried deeper; other studies indicate that infection is greatest when sclerotia are left on the soil surface. In any case, sclerotia that are within an inch of the soil surface are capable of producing apothecia, which liberate spores that may start new infections. Deep tillage (moldboard plowing) may be used to bury sclerotia after a susceptible crop has been heavily infected; this practice will help reduce *Sclerotinia* spore showers in subsequent years if the sclerotia remain deeply buried, but not if deep tillage is used the following year.

Burial of sclerotia may or may not result in their longer survival. If deep tillage is used to bury sclerotia, shallow tillage, such as chisel plowing, should be used for the next two or three years to assure that sclerotia are not returned to the soil surface, where they can produce apothecia and liberate spores. Deep tillage is of limited value if used on only a few fields in an area that has many infested fields; it may be more effective if practiced areawide.

Biological Control: Intercept is a biological control product registered for control of Sclerotinia. It contains *Coniothyrium minitans*, a fungus that attacks the sclerotia in the soil and kills them. Several months are required for the fungus to kill the sclerotia. Since this product is new, very little field data is available from North Dakota and Minnesota on how well it controls Sclerotinia.

Varieties: Although all varieties are susceptible, some are less susceptible than others and will perform better under moderate to severe disease pressure. Research has been initiated to test for varieties that are less susceptible. Some varieties are available that are **apetalous**, which means they have no petals. This removes a major food source for *Sclerotinia*, and apetalous varieties escape a severe infection incidence. Apetalous varieties may be useful if they yield as well as conventional varieties.

Fungicides: Quadris was registered for suppression of Sclerotinia on canola in March 1999, Ronilan was registered in June 2000, Topsin M was registered in June 2002 and Endura was registered in July 2003. Other fungicides may be registered within the next several years. Information on registered fungicides is available in the most current edition of the *North Dakota Field Crop Fungicide Guide* (PP-622), from county Extension offices, NDSU and University of Minnesota Research Extension Centers, the Northern Canola Growers Association and the Minnesota Canola Council.

Timing: Effective suppression of Sclerotinia requires timely application of a fungicide. Quadris should be applied at 10 percent to 25 percent bloom, or three to seven days after initiation of bloom. The main stem of Argentine canola will have 10 to 18 flowers when it is at 10 percent to 25 percent bloom. Quadris should be applied before or as the first petals begin to fall. Late application of Quadris is less effective than timely application.

Ronilan, Topsin M and Endura should be applied at 20 percent to 50 percent bloom, or four to eight days after initiation of bloom. The main stem will have 14 to 16 flowers at 20 percent bloom and 20 or more (includes any flowers that have dropped off) at 30 percent bloom. The 50 percent bloom stage is the time of maximum color development in the crop. At that stage, pods will be on the lower one third of the main stem. Once the crop is beyond 50 percent bloom, Ronilan, Topsin M and Endura are less effective for *Sclerotinia* control. Fungicide trials in more than two years indicated that both Ronilan and Topsin M were more effective when applied at 35 percent to 50 percent bloom than when applied earlier.

Rates: Quadris should be applied at 9.6 to 13.8 fluid ounces per acre. The registrant, Syngenta, has supported the 9.6 fl oz rate, and that rate may provide adequate control if applied before any petals begin to fall. Results with Quadris have been variable, however.

Ronilan should be applied at 10.6 to 16 oz/A. Extensive data from North Dakota, Minnesota and Canada indicates that the 12 oz rate provides excellent and consistent Sclerotinia suppression under even severe disease pressure. The 10.6 oz rate is slightly less effective, but may be adequate for moderate disease pressure.

Topsin M should be applied once at 1 to 2 lb/A at 20 percent to 50 percent bloom or twice at 1 lb/A for each application, with the first application at 20 percent to 30 percent bloom and the second at 40 percent to 50 percent bloom. One application of the 1 lb/A rate has performed very well at 35 percent to 50 percent flowering in most trials in Minnesota and North Dakota.

Endura should be applied up to two times at 5 to 6 oz/A at 20 percent to 50 percent bloom. One application at 35 percent to 50 percent flowering has performed very well in trials in North Dakota.

Spray decisions: Fungicides for suppression of Sclerotinia are expensive and the decision to spray should be made only when: 1) yield potential is above normal (at least 40 bushels or 2,000 lb/A) if canola prices are minimal, 2) weather leading to early bloom has been wet (at least 1 to 2 inches of rain in the two weeks prior to early bloom), 3) more rain or high humidity is expected, and 4) *Sclerotinia* has been a problem in recent years in fields currently planted to canola or in fields nearby. A fungicide more likely will be needed if canola is on tight rotations (three years or less) or if other susceptible crops were in the rotation.

A Sclerotinia risk map, similar to that used in Canada, was initiated in 2001 for North Dakota and northwest Minnesota. The risk map is posted on the Northern Canola Growers Association Web site: *www.northerncanola.com/maps/index.asp* and the NDSU Web site: *www.ag.ndsu.nodak.edu/aginfo/sclerotinia/sclerotinia.htm*.

The risk map site contains three maps: a map showing the growth stage of canola, a map showing soil moisture and where the soil is at field capacity, and a map showing the risk from Sclerotinia.

A risk assessment checklist follows. This checklist was reproduced, with permission, from the Canola Council of Canada Web site.

Sclerotinia Stem Rot Checklist

Reproduced from the Canola Council of Canada Web site, by permission

When to complete the checklist:
Fill out the checklist and assess the crop shortly after first flower. First flower occurs when 75 percent of the canola plants have three open flowers on the main stem. Usually this occurs during the last week of June or the first week of July.

How to complete the checklist:
Read each question and circle the point value assigned to the answer you choose. Count up the points for each question and enter the total for each section. Answer all the questions in this section.

SECTION ONE:

1. Have you had good looking crops at flowering and poor yields at harvest, even though growing conditions were favorable?	Yes - 20	No - 0
2. Have you seen sclerotinia stem rot in your crops in previous years?	Yes - 20	No - 10
3. Have you heard of sclerotinia problems in your area in the past two to three years?	Yes - 10	No - 5
4. Have you seen black sclerotes (sclerotia) in your harvested seed in the past two to three years?	Yes - 20	No - 10
5. In previous years have your canola crops lodged?	Heavily Moderately Lightly	- 20 - 10 - 0
6. Do you see large swaths at harvest but get low yield?	Yes - 10	No - 0
7. If you sprayed a sclerotinia fungicide in previous years, what were the results?	Better crop No difference	- 20 - 0
Total points for section one =	Total	

If you scored 60 or more in this section you probably had sclerotinia stem rot in your canola crops. Proceed to section two with a 60 or more score.

SECTION TWO:

8. When you walk through the crop during the morning at the beginning of flowering are your boots and pant legs wet when you come out?	Yes – 20	No – 10

9. Have you had wet weather in the immediate area within 2 to 3 weeks prior to flowering that allowed the soil to remain moist for extended periods?	Yes - 20	No - 10
10. Were apothecia found in the field, around the field, or in any neighboring cereal or canola fields where canola was grown in the previous 1 to 3 years?	Yes - 20	No - 10
11. Do you feel it will be dry throughout the flowering stage of the crop?	Highly likely Mod. likely Not likely	- 0 - 10 - 20
Total points for section two =	Total	

If you had a high score in section one and more than 50 for section two, you should consider applying a fungicide to protect your crop against sclerotinia stem rot.

SECTION THREE:

12. What is the condition of your stand of canola in terms of height, vigor and uniformity?	Excellent Good Fair Poor	- 20 - 10 - 5 - 0
13. When you walk through your crop, how dense is the canopy?	Light Moderate Very Dense	- 0 - 10 - 20
14. What is the yield potential of the stand?	10 – 20 bu/A 20 – 30 bu/A > 30 bu/A	- 0 - 10 - 20
15. In previous years, when your yield potential was 30+ bu/A, what were the actual yields?	> 30 bu/A 20 - 30 bu/A	- 0 - 20
Total points for section three =	Total	

If you scored 50 or higher in section three, along with high scores from the first and second sections (60 and 50-plus respectively), protecting your crop against sclerotinia stem rot may be worthwhile. If you scored less than 50 in the last section, it likely is not worth applying a foliar fungicide.

Permission by the Canola Council of Canada to reproduce this checklist is gratefully acknowledged.

Alternaria Black Spot

Appearance

Spots may develop at flowering on the leaves. These spots may be gray, gray with a dark border, or black. A yellowish halo often surrounds the leaf spots. Black spots may develop on stems and pods. Severely spotted pods may contain shrunken seeds infested with the fungus. Green seeds often are found next to deeply penetrating pod spots, resulting in green seed formation and low test weight seed. Black spot usually is less severe in Argentine canola *(B. napus)* than in Polish canola *(B. rapa)*. Severely infected pods may split prematurely, resulting in seed shattering.

Survival and Spread

The fungi *Alternaria brassicae* and *A. japonica* survive on infected canola stubble and infested seeds. Plants are infected directly from infested seeds or from spores produced on infected canola residue. The fungi also infect several weeds in the mustard family and survive on them. Frequent rains, fog or heavy dew and temperatures around 70 F during podding and ripening favor severe outbreaks of black spot.

Disease Management

Buy certified, germination tested seed that has been cleaned properly. Most seed treatment fungicides that are effective against blackleg also will help control seed-borne black spot. Use well-balanced fertilizer applications, as stressed plants are more susceptible to black spot. When swathing, avoid a heavy swath; instead, choose a light swath that will dry more rapidly. Combine as soon as possible. Quadris fungicide, applied at 95 percent bloom, can reduce black spot damage and green seed, plus increase yields by several hundred pounds.

White Rust (Staghead)

Appearance

This disease commonly occurs on Polish canola *(B. rapa)*, as well as on brown and oriental mustard *(B. juncea)*. The most obvious symptoms of white rust are the swollen flowering stems and pods. These swollen tissues may be spiny, resulting in the name staghead. The stagheads are green when formed, later turning brown. In wet weather, powdery white spore masses develop on the stagheads, stems and lower surfaces of leaves. Severely diseased leaves may turn yellow and drop. Yellowing leaves may develop "green islands" of tissue over each pustule.

Survival and Spread

The fungus *Albugo candida* survives as thick-walled spores in the stagheads, many of which fall to the ground during harvest. Many stagheads are broken up during combining, resulting in release of the spores. The following spring, these thick-walled spores germinate and infect the cotyledons and leaves of young plants. Secondary spread to the flower parts occurs from a second type of spore.

Disease Management

All Argentine *(B. napus)* varieties are resistant to white rust. Most Polish canola *(B. rapa)* varieties are susceptible, but a few newer varieties are moderately susceptible, moderately resistant or resistant. Seed of susceptible Polish varieties should be cleaned thoroughly to remove staghead fragments from the seed. Do not plant canola on canola if susceptible varieties are being grown. Control volunteer canola and wild mustard early in the season, as these are a source of the fungus.

Downy Mildew

Appearance

A white mealy growth develops on the lower surfaces of leaves. The upper leaf surface opposite the infected area turns yellow. Downy mildew can also be found on the green stagheads, caused by the white rust fungus.

Survival and Spread

Cool moist weather favors the downy mildew fungus, *Peronospora parasitica*. It frequently occurs in association with white rust, and the disease complex usually is more serious than either disease alone.

Disease Management

No suitable management is available.

Root Rot

Several root and crown rots have been reported in North America. Seed decay and seedling diseases may occur, but usually are of minor importance. Root rot (basal stem rot) that *Fusarium* spp. and *Rhizoctonia solani* cause may develop late in the season, producing basal lesions with black borders and salmon-colored spore masses on the lesion surfaces. Basal cankers may cause plants to ripen prematurely. Brown girdling stem rot, that *Rhizoctonia solani* primarily causes, is a serious disease of Polish canola *(B. rapa)* in the Peace River region of northern Alberta, but is not important elsewhere. A crown rot that Rhizoctonia sp. causes was reported in Indiana. No serious seedling disease or root rot problems have been reported to date in Minnesota or North Dakota.

Clubroot

Clubroot is a destructive disease of many crops in the cabbage family. It has not yet appeared in the prairie provinces of Canada or in North Dakota, but was observed once in northern Minnesota.

Appearance
Galls and club-shaped growths appear on roots. The galls are firm and white, later becoming soft and gray-brown. Severely infected plants are stunted and may wilt.

Survival and Spread
Resting spores of the fungus *Plasmodiophora brassicae* survive many years in the soil. When soils are wet and susceptible roots are near, the resting spores germinate, producing swimming spores (zoospores) that infect the roots. Cultivating equipment moving soil from field to field spreads the disease.

Disease Management
No satisfactory management exists. Alkaline soils are less conducive to clubroot than acid soils. In acid soils, liming may reduce severity. Avoid introducing soil from infested areas, e.g., on equipment or cabbage seedlings from Wisconsin, the eastern United States, eastern Canada or the Pacific Northwest.

Aster Yellows

Appearance
Distorted and sterile flowers are formed. Flowering portions of the plant may show excess branching and stunting (shortened internodes), resulting in a "witches'-broom" appearance. Inflated round or oval blue-green bladderlike structures replace the pods. Infected plants produce little seed, but the percent of infected plants usually is quite low. An exception was noted in 1999, when infection was noticeable in many fields in Minnesota and North Dakota, and economic losses occurred in a few fields.

Survival and Spread
The aster yellows phytoplasma does not survive the winter in Minnesota or North Dakota.

The aster leafhopper, *Macrosteles fascifrons*, transmits it. The amount of aster yellows depends on the number of

leafhoppers that migrate in from overwintering areas to the south, the percent of leafhoppers carrying the aster yellows phytoplasma and the leafhoppers' arrival time.

Disease Management

The disease is rarely economic. Early planting may reduce the incidence of aster yellows.

Fusarium Wilt

Appearance

Affected plants first will exhibit stunting and foliar discoloration, and eventually may wilt. Pods of infected plants may be reduced in size and have few to no seeds. Yellow to brown streaking along one side of the stem of infected plants also may be observed.

Survival and Spread

In Canada, either of the fungi *Fusarium avenaceum* or *F. oxysporum* can cause fusarium wilt. The pathogens survive in the soil. Little is known about the infection process, but symptoms may be more severe under hot and dry environmental conditions.

Disease Management

This disease has not been observed in the United States; however, it most likely will occur in the future. Crop rotation with cereal crops may reduce inoculum levels in the field. Data collected in Canada has shown that differences in cultivar susceptibility occur.

Crop Rotation and Disease

Short crop rotations promote the buildup of certain diseases; others are not affected or are affected only slightly.

Blackleg

Rotation directly affects blackleg, with the greatest blackleg incidence (percent of infected plants) developing

where canola is planted on canola, followed by canola separated by only one crop from the previous canola crop, followed by canola every three, four and five years. Data from north-central North Dakota, as well as extensive data from a three-year study in Manitoba and rotation experiments in Alberta, all substantiate this.

Canola should not be planted on canola or separated from canola by only one crop. For any short canola rotation or when planting next to last year's canola field, select a variety or hybrid that is resistant or moderately resistant to blackleg. If canola is grown consistently on short rotations, blackleg may become a problem, even when planting a resistant variety, because of heavy disease pressure.

Blackleg spores are wind-borne. The greatest threat from wind-borne spores is from infected canola stubble that is one-half to one mile away, although some spores may cause infection in fields up to three miles away. In areas where most fields are on a three-year canola rotation, any canola field planted likely will be next to or near a field that had canola the previous year. Using varieties that are resistant or moderately resistant to blackleg will help minimize the amount of blackleg infection in these areas.

Burying blackleg-infected canola residue helps reduce the threat of blackleg to subsequent crops. Canola crop residue will continue to produce blackleg spores until it has decomposed. Burying canola crop residue prevents spore release and helps hasten decomposition of the canola residue.

Alternaria Black Spot

Short rotations also favor Alternaria black spot. Increasing the length of rotations to reduce the threat of blackleg also will reduce the threat of Alternaria black spot.

Sclerotinia Stem Rot

The above studies do not show any consistent relationship between length of canola rotations and Sclerotinia

stem rot incidence. Airborne spores cause Sclerotinia infections, but these spores may blow in from nearby fields. The concentration of Sclerotinia-susceptible crops that have been grown in an area for the past four years and the amount of Sclerotinia infection in these past crops may provide the most reliable estimate of Sclerotinia potential. Crop rotation is of limited value for the management of Sclerotinia. However, growing only one crop that is highly susceptible to Sclerotinia in a rotation is important since this minimizes the disease pressure within the field. *See the following section on Sclerotinia and Crop Rotations*.

Sclerotinia and Crop Rotations

Avoid planting more than one crop that is highly susceptible to Sclerotinia in a crop rotation. The most susceptible crops include sunflowers, dry beans, canola, crambe, mustard, chickpeas and borage; only one of these crops should be in a rotation. Soybeans, lentils, viney field peas and lupins are moderately susceptible. Flax, buckwheat and semi-leafless field peas are least susceptible. These crops are unlikely to sustain any serious losses from Sclerotinia. In addition, both buckwheat and semi-leafless field peas produce very few sclerotia, so these crops will do little to maintain a population of Sclerotinia in the soil. Flax produces no sclerotia, so it will not contribute to maintaining a Sclerotinia population.

Small grains, corn and other members of the cereal grass family are immune to Sclerotinia; they are good rotational crops with highly susceptible crops. Many broad-leaf weeds, including wild mustard, pigweed, lambsquarters, marshelder, Canada thistle and burdock, are hosts of Sclerotinia. These weeds need to be controlled when growing an immune crop; otherwise broad-leaf weeds will help maintain a Sclerotinia population in the soil when Sclerotinia-immune crops are being grown.

Frost Tolerance and Frost Damage

Frost can occur in any month, but those in spring and late August or early September are critical. The temperature at which freezing injury occurs varies with the plant's stage of growth, moisture content and the length of time the temperature remains below freezing. Damage occurs when ice crystals form within the plant or the plant actually freezes, causing cell walls to rupture. A severe drop in temperature, which lasts only a very short time, may not damage canola plants, while a light frost of several degrees below freezing that lasts all night may cause severe damage. The amount of frost injury will depend on soil moisture conditions, the rate at which thawing occurs, the growth stage of the plants and the amount of cold temperature hardening that the plant is exposed to prior to freezing temperatures.

Canola seedlings usually will recover from a light spring frost that does not damage the growing point of the plant. If a heavy frost does blacken the leaves, don't take any action for at least four to seven days. The extent of injury can be determined in a week or less following the frost. If any green color is at the growing point in the center of the frozen leaf rosette, the plant will recover and yields will be higher than if the field is torn up, reworked and reseeded.

Early seeded canola, after several days of near-freezing temperatures, will undergo a gradual hardening process that will allow the plants to withstand freezing temperatures without serious damage. A number of chemical changes occur, resulting in a higher concentration of soluble substances in the cell sap. Research in Canada has shown that early seeded canola that had undergone hardening could withstand 18 to 20 F temperatures, while temperatures of 25 to 26 F killed later sown canola that did not undergo hardening. In North Dakota, canola

seedlings have withstood temperatures as low as 22 to 23 F with only limited frost damage or stand reduction.

In evaluating frosted seedling fields, producers must consider the percentage of plants killed, the percentage recovered and the time of year. The surviving plants also should be somewhat evenly distributed in a field when allowing the stand to remain for production and yield. Even if two-thirds of the seedlings in a reasonable stand are frost killed, the field usually will produce more when left than if reseeded. The surviving plants will take advantage of the reduced competition for light, moisture and nutrients, and grow larger, producing more branches, pods and seeds per pod, thereby compensating for the lost plants. The surviving plants will require five to eight days longer to mature; but a reseeded crop will require an even longer period.

Frost at flowering will delay maturity but results in only minor yield reductions. Frost after flowering, however, can result in significant yield reductions and grade loss. Frost during flowering usually causes flower abortion. Researchers have observed that only plants with open flowers at the time of the frost were affected. Pods lower down on the stems and unopened buds continued to develop normally. Several days after the frost injury, gaps of aborted pods were evident on the stems. The injury was quite evident; all open flowers at the time of the frost showed the damage.

The amount of fall frost damage to canola depends on the stage of maturity. A 27 F frost is enough to kill immature seeds containing 50 percent to 60 percent moisture, while those ready to swath at about 35 percent moisture normally will escape damage. Thus, having uniform stands that ripen uniformly early is important. Uneven stands, with a significant portion of late, immature seeds, may produce lower quality seeds since the damaged

seeds will retain their green color, which will reduce the grade.

Hail Damage in Canola

When hail storms occur, what kind of damage and injury can producers expect? A general rule is that the earlier in canola plant development, the more time to recover and the less amount of total hail injury.

Plantings in seedling stages can have stands reduced by 50 percent and still produce acceptable yields (**Table 1**). Prior to bolting and flower development, canola can withstand hail without much economic loss. Canola plants with leaves that are torn and shredded suffer only partial loss, while leaves bruised on the main vein or torn and broken will be lost. Leaf area destroyed will result in seed yield loss. Seed yield losses in canola are approximately 25 percent of leaf area lost. If leaf defoliation were 50 percent, then yield loss would be approximately 12.5 percent in the seedling stage (**Table 2**).

Canola plants injured in late bolting or early flowering stages seldom die. The well-developed root systems and ability to rebranch and develop secondary flower clusters help the plants recover. When buds or flowers are destroyed, the canola recovers rapidly by development of flowers, which normally would have aborted. New branches also develop from growth buds lower down on the plant.

Seed yield loss will depend on both percent of leaves and branches lost. For example, if canola has 60 percent lost branches seven days into flowering, seed yield loss is estimated at 18 percent, whereas 21 days into flowering, yield loss would be an estimated 60 percent.

If hail strikes late, such as during pod filling or ripening, plant recovery is not possible. The time needed to develop new growth, flowers and mature is limited before a killing frost. If injury occurs at the ripening stage, canola seed yield loss depends directly on the loss of branches, individual pods and seed knocked out of pods. Severe hail losses have occurred in canola swaths with excessive pod shattering causing economic seed loss.

Table 1. Percent yield loss from canola stand reduction.

Original plants/ 10 feet of row	Percent Stand Reduction									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
30-80	0	0	4	7	12	27	47	72	90	100
less than 30	10	20	30	40	50	60	70	80	90	100

Table 2. Percent yield loss from defoliation of canola.

	Average percentage of leaf area destroyed									
Stage of Growth	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Vegetative through start of flowering	2	4	6	10	12	15	18	20	22	25
5 days after flowering	2	3	5	6	8	10	11	13	14	16
10 days after flowering up thru branching	1	2	2	3	4	5	6	6	7	8

Source: National Crop Insurance Service

Swathing and Harvest Management

Swathing canola at the optimum stage of ripening reduces green seed problems and seed shatter losses, and ensures the quality required for top grades and prices. Inspect fields every two to three days when some color change is in the first formed pods on the bottom of the main stem.

To determine when a field of canola is ready to swath, examine plants from different parts of the field. The stage of maturity in an evenly maturing field will vary from plant to plant and from area to area within the field. When examining the plants, take into account varying soil types, low-lying areas, available soil moisture and exposed early ripening areas.

Examine only those pods on the main stem. Seeds in pods on the bottom third of the main stem were formed earlier and will turn color much sooner than seeds in the pods on the top third of the plant. When the overall moisture content of seed from the total plant averages 30 percent to 35 percent, about 30 percent to 40 percent of the seeds in pods on the main stem will have changed color or have started to change color. Seeds with only small patches of color should be counted as color changed. Remember, the color of the seed is more important than the overall color of the field in determining the stage of maturity.

Most of the seeds that have changed color will be from the bottom third of the main stem. When seeds in the bottom pods slightly turn color, seeds in the top, last-formed pods are filled or nearly filled.

Seeds in all pods on a plant complete filling (physiological maturity) at about 40 percent moisture and then slowly turn from green to light yellow, or reddish-brown, brown or black, depending on the

variety. In hot (90 F), dry weather, canola seed can go from 10 percent to 50 percent seed color change in just three to five days or less. Once filled, the seeds rapidly lose moisture at about 2 to 3 percentage points or more each day, depending on the weather.

Swathing early can be beneficial if a hard fall frost is expected. Frost fixes the chlorophyll or green color in immature seed, making it difficult to remove during processing. Fall frosts rarely freeze to ground level. A swathed crop will not only lie below the coldest night temperatures, but much of the seed will benefit from the insulating properties of the swath and residual soil heat, preventing or reducing frost-fixed chlorophyll.

Another sign of canola being very near the swathing stage is the natural yellowing and senescence of leaves and leaf drop. When canola plants consist only of stems, stem branches and pods, the crop probably is very near the optimum time for swathing. With large acreage of canola, swathing should start when seed color change is approximately 20 percent to 25 percent and the majority of the crop can be cut at or near the optimum seed color. Swathing can begin in Argentine canola as early as 15 percent seed color change. Polish canola should be left until 20 percent to 25 percent seed color change.

Cutting Height: The swather should be run just low enough to get all the seed pods, leaving the maximum amount of stubble to anchor the windrow and ensure adequate air circulation through the windrow. Most stubble height varies from 10 to 12 inches in canola fields after swathing.

Swather Table and Throat: The windrow must flow smoothly through the swather without bunching. Bunching leads to uneven drying and combine plugging. Therefore, a good swather must have enough depth of table (40 inches) to handle the crop material.

It also should have a large throat opening at least as wide (40 to 54 inches) as the distance between the two swather canvasses on center-delivery swathers. It should have a vertical clearance for the windrow of at least 30 to 40 inches.

The table canvas should be strong enough to carry the heavy load of the material cut and should be run just fast enough to keep the table clean. If possible, canvas speed should be varied, depending on the maturity of the crop cut. A fast canvas tends to produce a hollow, twisted windrow; a slower canvas produces a more compact windrow, but it may bunch and sit high on the stubble. Increase the canvas speed until the windrow is pressed into the stubble.

The reel should be set as high and far forward as possible. Reel speed should be set to correspond with the swather's forward speed. Finger reels work best in canola to help bring the material back onto the table and gently handle the ripened canola. For a lodged or leaning canola crop, use finger reels for ease of swathing.

Ordinary end dividers, which are long and gently sloping, generally are less prone to plugging than short, abrupt types. When the crop is tall, tangled and lodged, or laid across the seeded rows, divider plugging almost is inevitable unless the swather is fitted with special vertical cutterbars or power blades. These can cause minor loss of pods and whole seed tops, but they prevent stops and bunching. In badly lodged crops, swathing in a direction parallel to the direction in which the crop is leaning may be advantageous.

In areas where windrows could be lifted and blown by the wind, a light roller pulled behind the swather will help anchor the windrow in the stubble. The roller should be set so that it just anchors the windrow into the stubble without shelling any ripe pods. Excessive roller

pressure will produce a windrow that is too compact to dry quickly and difficult to pick up without shelling the canola. NDSU research studies have shown that swath pack density and seeding rates had little effect on green seed of canola.

Swathing Overly Ripe Fields: Swathing late, when seed moisture content is much lower (about 80 percent seed color change), will result in fluffy windrows susceptible to blowing and increased shattering. To reduce shattering losses, overripe fields should be swathed when humidity is high, such as after a rain or heavy dew, or at night.

Swathing Unevenly Maturing Crops: Determining when to swath unevenly maturing fields is difficult. When checking uneven stands, a producer should do an early count on the ratio of early emerged canola, which is bolting or starting to flower, and the late emerged flush of young, more immature plants. Knowing the ratio of early to late emerged canola plants allows produces to make a better decision as to how soon to swath or whether to wait until the later crop catches up. If the stand is 20 percent to 25 percent early and 75 percent to 80 percent late, then waiting to cut later may be the best strategy to reduce the amount of green seed.

Curing in the Swath: Canola should be allowed to cure and ripen from 10 to14 days in the swath before combining. If combined too early, the chance of increased green seed in the harvested crop is much greater. While starting on the early side is better for swathing, the same doesn't necessarily hold true for combining. Hot or windy weather at or after swathing can cause canola seed to be at the appropriate moisture content for combining before it has cured and cleared the green chlorophyll. This occurs because the plant dries up before sufficient moisture can move into the seed to finish curing it. Canola requires at least 20 percent moisture in the seed for the maturing process to take place and

eliminate the green seed color. Checking both moisture content and green seed count before starting to combine is important. Delayed combining can help clear the green color, particularly if the swath sits through several heavy dews or light rain showers.

Practices to Reduce Green Seed: Growers can make management decisions to reduce green seed problems.

- Choose fields with better surface drainage and fertility.
- Seed as early as possible in the spring to allow for the maximum ripening time.
- Provide a firm seedbed to achieve correct depth of planting and good seed-to-soil contact for rapid and even emergence. Do not broadcast seed!
- Swath at the recommended color stage for the weather conditions.
- Maintain adequate fertility levels for canola growth and ripening. Canola stressed from sulfur nutrient deficiency will not mature evenly.
- Take soil samples for a general indication of N, P, K and sulfur.
- Sample plant tissue early during rosette stage to allow time for corrective sulfur applications.
- Fields with high fertility levels can be expected to delay maturity in years with below-normal growing degree day (GDD) accumulation or heat units (cool years).
- Don't swath canola if the weather forecast is for extremely hot, dry and windy conditions.
- All canola management decisions should be targeted toward uniform crop maturity.

Combining: All combines work fairly well to harvest canola. Combines should be checked out thoroughly before starting on canola. Use duct tape or caulking

compound to cover any holes or worn spots in the table/platform or within a combine. Leakage can occur easily in the stone trap, top feeder housing or through lower inspection doors.

Travel speed of the combine should be equal to that of the pickup so a gentle lifting of the swath occurs without tearing or pushing. Set the pickup to rub just under the swath.

Cylinder speeds will depend on canola crop conditions. Speeds of one-half to two-thirds of that used for small grains often are used for canola. The speed should be just fast enough to break open the pods. Speed reduction is important to prevent overthreshing of pods and stems and overloading the sieves. The impact when the cylinder speed is too fast causes cracked canola. Examine the threshed seed for cracked canola. Push your arm into the seeds and observe if cracked canola seed pieces stick to your skin or the hair on your arm. Reduce cylinder speeds if excessive cracking does occur.

Fan speed should be set low to avoid blowing canola seed out with the chaff. This will allow large amounts of pods in the return. Start with low fan speed and increase gradually until separation of chaff and seed occurs with no canola being blown over the chaffer sieve.

Direct cutting of Polish canola results in little or no shatter loss. However, direct cut combining of Argentine-type canola has resulted in yield losses of 8 percent to 54 percent, as reported by the Canola Production Center in Canada. These losses primarily were from preharvest shattering and gathering shattering losses when canola was taken into the combine.

Canola Drying and Storage Management

Harvesting at the proper stage is very important in having a good quality product. The seed needs to be yellow or brown before harvesting. If more than 2 percent of the seed is green, the canola is discounted severely at marketing. Color will not change during drying and storage.

Canola is a small, round seed that flows freely, so tight containers are required to store it. The density of canola is specified at 50 pounds per bushel.

The recommended moisture content for storage is 8 percent. Storing 10 percent moisture canola at 80 F would be similar to storing wheat at 15 percent. The allowable storage time would be about 70 days. Determine the allowable storage time from a chart for cereal grains by subtracting 5 percent from the cereal grain moisture content. For example, the allowable storage time of 18 percent wheat at 60 F is about 50 days, so the estimated allowable storage time for 13 percent canola at 60 F is about 50 days.

Storage management, including aeration, is critical. Heating lowers protein quality and causes large increases in the amount of free fatty acid in the canola, which greatly reduces its value. Canola goes through a "sweat," a period of high respiration rate producing heat and moisture, during the first month of storage. The sweating will be worse at higher moisture contents and temperatures. Aeration and frequently monitoring the canola during this period are very important. The canola should be aerated within days after being placed in storage, then cooled whenever average outdoor temperatures are 10 to 15 F cooler than the canola. Cool canola to about 20 to 25 F for winter storage. Storage management is similar to storing grain.

The type of canola affects the aeration system design, operating static pressure, airflow and fan selected. For example, to obtain an airflow rate of 0.2 cfm/bu (cubic feet per minute/bushel) in a 21-foot diameter bin filled 20 feet deep with *B. napus* (Argentine) canola requires a 0.9 horsepower fan operating at 3 inches of static pressure. The Argentine is the most common type of canola grown. To obtain that same airflow rate through *B. rapa* (Polish) canola requires a 1.3 horsepower fan operating at 4.5 inches of static pressure. If a 1.5 horsepower, 18-inch axial fan is placed on the 21-foot diameter bin filled 20 feet deep with Argentine canola, an airflow rate of 0.22 cfm/bu is obtained. However, if the same fan is placed on the bin of Polish canola, an airflow rate of only 0.16 cfm/bu is obtained.

The resistance to airflow (static pressure) of Argentine canola is about twice that of wheat. Fans must be selected to operate at the appropriate static pressure. A computer program that calculates the static pressure and provides fan selection information is available at the NDSU Agriculture Web site.

Natural air/low temperature drying with an airflow rate of 0.75 cfm/bu. will dry canola at moisture contents up to 12 percent. An airflow rate of 1 cfm/bu permits drying canola with initial moisture contents up to 13 percent. Higher airflow rates are not economical due to the large resistance to airflow through canola. Estimated depths of Argentine canola at selected airflow rates and static pressures are shown in the following table.

Static Pressure	Airflow Rate (cfm/bu)	
(inch of water)	0.75	1.0
	Canola Depth	
6"	13 ft.	11 ft.
7"	14 ft.	12 ft.
8"	15 ft.	13 ft.

Based on the state's average climatic conditions, canola would be expected to dry to about 8 percent in August, 9 percent in September and 9.8 percent in October. The canola moisture content is expected to be lower due to the fan warming the air about 5 F. With this warmed air, the expected moisture contents are: August, 6.6 percent; September, 7.8 percent; and October, 8.2 percent. Supplemental heat may be added if canola does not reach the recommended storage moisture content using natural air drying. Do not warm the air more than 5 F or the canola will be overdried. The estimated drying time in September, using an airflow rate of 1 cfm/bu, is about 25 days, and about 35 days with an airflow rate of 0.75 cfm/bu.

The equilibrium moisture content of canola is shown in the following table.

Canola Equilibrium Moisture Content (EMC)

Relative Humidity	Temperature (F)						
	20	30	40	50	60	70	80
(%)							
20	4.9	4.5	4.1	3.8	3.6	3.4	3.2
30	6.5	5.9	5.5	5.1	4.8	4.5	4.3
40	8.1	7.4	6.8	6.3	6.0	5.6	5.3
50	9.6	8.8	8.1	7.6	7.1	6.8	6.4
60	11.3	10.3	9.6	9.0	8.4	8.0	7.6
70	13.1	12.1	11.2	10.5	10.0	9.3	8.9
80	15.4	14.2	13.2	12.3	11.6	11.0	10.5
90	18.6	17.2	16.0	15.0	14.2	13.5	12.8

Drying temperatures need to be limited during high-temperature drying. At moisture contents up to 12 percent, a drying temperature of 180 F can be used with dryers that mix the seed as it is dried. At moisture contents exceeding 12 percent, the dryer temperature

needs to be limited to 160 F, even with mixing occurring in the dryer. Without mixing, the dryer temperature needs to be limited to 140 F. Canola, which is used for seed, should be dried at temperatures less than 110 F. Canola offers more resistance to airflow than cereal grains, so airflow and the drying rate will be reduced. Chaff may interfere with the flow of canola in a dryer, which may lead to an overdried area and the potential for fires. Frequently check the dryer and periodically clean the dryer to reduce the fire hazard. Since canola seed is small, dryers may need to be modified to contain it.

USDA Market Grades and Grade Requirements of Canola.

U.S. Grades	1	2	3
Grading Factors maximum percent limits of:			
Damaged kernels			
Heat damaged	0.1	0.5	2.0
Distinctly green	2.0	6.0	20.0
Total	3.0	10.0	20.0
Conspicuous admixture*			
Ergot	0.05	0.05	0.05
Sclerotinia	0.05	0.10	0.15
Stones	0.05	0.05	0.05
Total	1.0	1.5	2.0
Inconspicuous admixture**	5.0	5.0	5.0
Maximum count limits of:			
Other Material			
Animal filth	3	3	3
Glass	0	0	0
Unknown foreign substance	1	1	1

U.S. Sample grade - Canola that:
- does not meet the requirements for U.S. Nos. 1, 2 or 3, or
- has a musty, sour or commercially objectionable foreign odor, or
- is heating or otherwise of distinctly low quality.

* **Conspicuous admixture** is all matter other than canola that is readily distinguishable from canola and which remains in the sample after the removal of machine-separated dockage. It is not limited to ergot, sclerotinia and stones.

** **Inconspicuous admixture.** Any seed which is difficult to distinguish from canola. This includes, but is not limited to, common wild mustard (*Brassica kaber* and *B. juncea*), domestic brown mustard *(Brassica juncea)*, yellow mustard *(B. hirta)*, and seed other than the mustard group.

Factors of most importance in the determination of grades are admixtures and soundness. Grading admixtures include such factors as foreign material, common wild mustard seed, tame brown and yellow mustard seed, earth pellets, sclerotinia, ergot and stones. Soundness refers to broken seed not assessed to dockage, seeds distinctly green after cracking, heat damage and odor.

Source: Federal Grain and Inspection Service, USDA.

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Useful Web Sites

North Dakota State University

Oilseeds and Row Crops
www.ag.ndsu.nodak.edu/plantsci/rowcrops/main.htm

North Dakota State University Extension Procrop:
www.ag.ndsu.nodak.edu/aginfo/procrop/procrop.htm

Sclerotinia Risk in Canaola Forecast Program
www.ag.ndsu.nodak.edu/aginfo/sclerotinia/sclerotinia.htm

Canola Insects Information
www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/index.htm#Cano

Canola Organizations

Northern Canola Growers Association
2718 Gateway Ave., #301, Bismarck, ND 58503
Tele: (701) 223-4124
Web address: *www.northerncanola.com/*

Minnesota Canola Council
1306 W. County Road F, #109
St. Paul, MN 55122
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U.S. Canola Association
600 Pennsylvania Ave. S.E., Suite 320
Washington, D.C. 20003
Tele: (202) 969-8113
Web address: *www.uscanola.com/*

Canola Council of Canada
400 - 167 Lombard Ave.
Winnipeg, MB R3B 0T6
Tele: (204) 982-2100
Web address: *www.canola-council.org/*

Saskatchewan Department of Agriculture and Food
Web address: *www.agr.gov.sk.ca/Crops/Oilseeds.asp?firstpick=Crops&secondpick=Oilseeds*

Manitoba Department of Agriculture and Food
Web address: *www.gov.mb.ca/agriculture/crops/index.html*

Resource Publications

NDSU Extension Service publications —

A-686	Canola Production
A-1124	Canola Variety Trials
SF-1122	Fertilizing Mustard and Canola
W-253	North Dakota Weed Control Guide
PP-1024	Blackleg of Canola
PP-1201	Sclerotinia Stem Rot of Canola
A-1208	Canola Flowering and Fungicide Application Timing
A-1171	Swathing and Harvesting of Canola
E-1143	North Dakota Field Crop Insect Management Guide
PP-622	North Dakota Field Crop Fungicide Guide
E-1234	Biology and Integrated Pest Management of the Crucifer Flea Beetle in Canola

Canola Growers Manual, Canola Council of Canada

2-leaf seedling
(photo courtesy of Canola Council of Canada)

early season sulfur deficiency

later season sulfur deficiency

stages of maturity

various pod maturity

seed maturity

ready to swath

swather with cutter bar

rolling canola

swaths of canola

ready to combine

▼ Weeds

barnyard grass

green foxtail

wild oat

biennial wormwood seedling

yellow foxtail

black nightshade

Canada thistle from root

Canada thistle seedling

cocklebur

common mallow

common ragweed

false chamomile

field bindweed

kochia

lambsquarters

marshelder

Pennsylvania smartweed

perennial sowthistle

pigweed

wild mustard

Russian thistle

wild sunflower

wild buckwheat

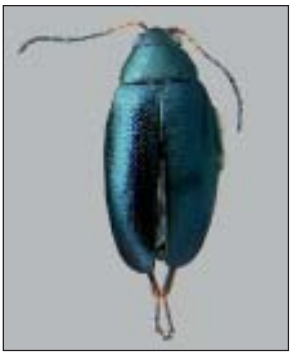

Figure 1a. Adult crucifer flea beetle, *Phyllotreta cruciferae* Goeze

Figure 1b. Adult stripped flea beetle, *Phyllotreta striolata* (Fabricius)

Figure 2. Damaged canola seedling caused by flea beetle feeding injury *(top)* and undamaged seedling *(bottom)*

Figure 3. Adult diamondback moth, *Plutella xylostella* (Linnaeus)

Figure 4a. Larvae of diamondback moth

Figure 4b. Damage from diamondback moth larvae (aborted flowers)

Figure 5. Adult bertha armyworm, *Mamestra configurata* Walker

Figure 6. Black *(right)* and green *(below)* color phase of larvae of bertha armyworm

Figure 7. Damage caused to pods from feeding of larvae of bertha armyworm

Figure 8.
Adult tarnished plant bug,
Lygus lineolaris
(Palisot de Beauvois)

Figure 9. Nymph of
tarnished plant bug,
Lygus lineolaris
(Palisot de Beauvois)

Figure 10a.
Adult red-backed
cutworm,
Euxoa ochrogaster
(Guenee),
typical form

Figure 10b. Adult red-backed cutworm, *Euxoa ochrogaster* (Guenee), dark form

Figure 10c. Adult red-backed cutworm, *Euxoa ochrogaster* (Guenee), pale form

Figure 11. Larvae of red-backed cutworm

Figure 12. Adult twostripped grasshopper, *Melanoplus bitvittatus* (Say)

Figure 13. Adult Nuttall blister beetle, *Lytta nuttalli* Say

Figure 14. Cluster of turnip aphids (*Lipaphis erysimi* (Kaltenbach)) on canola terminal

Insect Photograph Credits

Figures 2, 4b, 6, 7, 11, 12, 13 and 14 were taken by Janet Knodel.

Figures 1ab, 3, 5, and 10abc were taken by Gerald Fauske, Dept. Entomology, NDSU, Fargo, N.D.

Figure 4a is taken by Clyde Gorsuch, Clemson University, USDA Cooperative Extension Slide Set Series.

Figures 8 and 9 are taken by Scott Bauer of ARS, USDA.

▼ Disease

alternaria black spot

aster yellows

blackleg canker

aster yellows (close up)

blackleg foliar lesion

clubroot

fusarium wilt

rhizoctonia root rot

white rust (staghead)

sclerotinia stem rot

apothecia *(left)* of sclerotinia
(compared to a small mushroom)

List of Photograph Credits

All photographs were taken by NDSU contributors to the Canola Production Field Guide unless listed below. Cover photo by Duane Berglund.

Diseases

Fusarium wilt — D. Kaminski, Manitoba Agriculture, Food and Rural Initiatives, Manitoba, Canada

Insects

Adult crucifer flea beetle, *Phyllotreta cruciferae* Goeze — G. Fauske, Entomology Department, NDSU, Fargo

Adult stripped flea beetle, *Phyllotreta striolata* (Fabricius) — G. Fauske, Entomology Department, NDSU, Fargo

Adult diamondback moth, *Plutella xylostella* (Linnaeus) — G. Fauske, Entomology Department, NDSU, Fargo

Larvae of diamondback moth — C. Gorsuch, Clemson University, U.S. Department of Agriculture Cooperative Extension Slide Set Series

Adult bertha armyworm, *Mamestra configurata* Walker — G. Fauske, Entomology Department, NDSU, Fargo

Adult tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) — S. Bauer, Agricultural Research Service, USDA

Nymph of tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) — S. Bauer, Agricultural Research Service, USDA

Adult red-backed cutworm, *Euxoa ochrogaster* (Guenee) — G. Fauske, Entomology Department, NDSU, Fargo