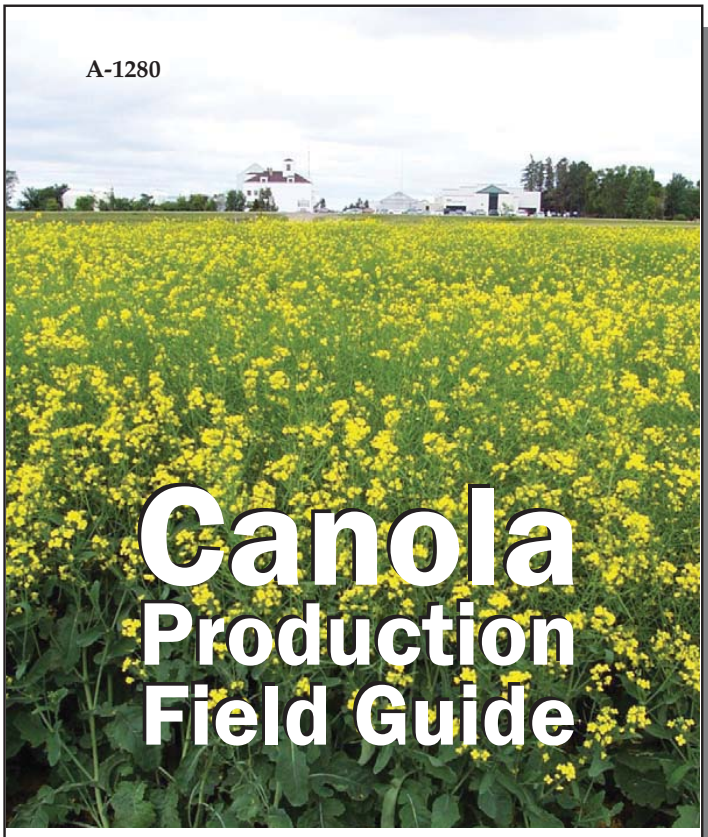
1

A-1280



Canola Production Field Guide

NDSU
Extension Service
North Dakota State University
June 2011

2

Edited and compiled by

Hans Kandel
Extension Agronomist
NDSU Extension Service

and

Janet J. Knodel
Extension Entomologist
NDSU Extension Service

Published in cooperation
and with support from the
Northern Canola Growers Association

Index

Introduction

Hans Kandel,
Extension Agronomist,
and
Duane R. Berglund,
Extension Agronomist Emeritus

Canola is a popular oilseed cash crop in North Dakota. North Dakota leads the U.S. in canola production with approximately 89 percent of the domestic production in 2010. About 1.27 million acres were harvested in North Dakota in 2010. That was the second highest acreage harvested in the last 15 years. Statewide yields have averaged from 1,230 to 1,840 pounds per acre during the past five years.

Canola is a specific edible type of rapeseed, developed in the 1970s, which contains about 40 percent oil. The term **"canola"** is a registered name by the Western Canadian Oilseed Crushers Association. Canola varieties must have an erucic acid content of less than 2 percent and less than 30 micromoles of glucosinolates per gram of seed. This makes it acceptable as an edible oil and animal protein feed. Canola oil is considered one of the highest quality edible oils available. 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 mostly is grown in Europe, although some production occurs in Canada and the U.S.

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 U.S., with only part of the demand being met by U.S. production. Canola oil has achieved worldwide commodity status and is extensively used in Japan, Canada and Europe.

Canola Varieties and Adaptations

Canola is the genetically altered form of rapeseed, which consists of three species: *Brassica napus*, known as Argentine canola; *Brassica rapa*, known as Polish Canola; and *Brassica juncea*, known as quality canola brown mustard. All species belong to the Brassicaceae (Cruciferae) family, also known as the mustard family.

Each canola species has distinct agronomic characteristics that should be considered when selecting a variety to grow. Spring and winter annual types are available in *B. napus* and *B. rapa*. Winter canola is not grown in North Dakota because of poor winter hardiness. However, winter canola planted in the fall sometimes has survived in yield trials in North Dakota and northwestern Minnesota.

Nearly all canola raised in North Dakota is spring-sown *B. napus*. In general, *B. napus* canola has higher oil content and is higher yielding (greater than 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

(B. rapa) varieties are more adapted to shorter growing seasons and where soil moisture may be limited. The main advantage of *B. rapa* canola vs. *B. napus* canola is if it is planted early, it flowers before the July heat, 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: open-pollinated, synthetic hybrids and hybrids. Hybrids and synthetic hybrids generally have higher yield potentials but also have higher seed cost. *B. juncea* canola was developed fairly recently in Canada. This species is more suitable to hot and dry conditions. *B. juncea* pods do not shatter as easily as other canola types. *B. juncea* canola is approved to grow in the U.S.

Herbicide-tolerant canola (HTC) varieties with resistance to a specific herbicide have been developed. Available HTC varieties include: Roundup Ready and Liberty-tolerant varieties that have been genetically modified and Clearfield (Imi) varieties that 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.

Markets are available for oils with specific 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** – *B. napus* canola varieties can mature 10 or more days later than *B. rapa*.
- **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. Canola growth is characterized by six main growth stages. The length of each growth stage is influenced by temperature, moisture, light, nutrition and variety.

Pre-emergence (Germination)

The germination process involves water absorption, swelling, splitting of the seed coat and emergence of the root tip. Cotyledons are pushed through the soil surface by an active hypocotyl. Germination typically takes from four to 10 days, depending on soil temperature and moisture, seed soil contact and planting depth. 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-borne pathogens and very susceptible to flea beetle injury. The growing point of canola is between the two cotyledons. The exposed growing point is susceptible to spring frosts, soil drifting, insects and hail damage. Canola is a very poor competitor with weeds, and good stand establishment is 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.
The rosette stage is characterized by an increase in leaf area index. 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 shades weeds.

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 "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 bud stage. Leaves are the major source of photosynthesis 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 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 completed approximately 35 to 45 days after flower initiation. The crop is considered ripe and ready to swath when 30 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 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 has similar moisture requirements as 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 or subsurface drainage is essential because canola cannot tolerate standing water or waterlogged soils. Do not till soils when they are too wet because, as soil clods dry, getting the proper soil-to-seed contact will be difficult. In regions of the state where the risk of heat and drought stress is high, avoid planting on light or sandy soil. Canola is less tolerant to drought than small-grain crops. Canola should not be planted on salt-affected soils because it is less tolerant than cereal grains.

Canola can be grown in a no-till or conventional tillage cropping system. Avoid excessive tillage in the spring to prevent the seedbed from drying out. Canola is very susceptible to soil crusting. The seedbed must be firm for seeding. Seed must be placed in moist soil. This is critical for rapid emergence. We do not recommend seeding canola into dry or excessively wet soils.

Planting Guidelines

Canola can be planted with a variety of seeding equipment. However, having good depth control is important. The optimum depth to seed canola is ½ to 1 inch. Seeding depth should not exceed an inch

with small-seeded canola varieties. Large-seeded hybrid varieties may be seeded deeper than 1 inch; however, planting depth should not exceed 1½ inches. Seeding canola where a uniform depth can be obtained always is best. We do not recommend broadcasting or spreading canola seed. In most cases where this has been tried, uneven emergence and poor stands have occurred. If broadcasting the seed is considered, incorporating the seed with a harrow is essential.

In no-till, we recommend an even distribution of residue on the surface over the seed slot to maintain moisture in the seed slot and allow shallow seeding.

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

If possible, canola should be planted prior to planting cereal grains. To maximize yield, canola should be planted in April to early May. Planting date research indicates that delayed planting beyond May 5 in the southwestern region, May 15 across most of the state and May 31 in the northeastern region may result in yield reductions. When deciding whether 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 southwestern regions of the state, no later than May 31 in the east-central and west-central regions of the state and no later than mid-June in the northern and northeastern regions of the state. Canola is very susceptible to heat and drought stress during flowering, and canola seedlings tolerate temperatures as low as 24 F.

Rates and Establishment

Canola seeding rates will vary depending on seed size. 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. A major difference occurs in seeds per pound among canola varieties. Adjust for these differences to avoid too thick or too thin of a stand.

The optimum seeding rate is 600,000 pure live seeds (PLS) per acre, which equates to 14 PLS per square foot. Knowing the number of seeds per pound and establishing a seeding rate by plant population is very important for a grower. 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. Seed counts for Polish varieties usually will be greater than 200,000 seeds per pound.

Seeding rate/plant population research indicates that planting 14 PLS per square foot should establish an optimum stand of eight to 12 plants per square foot. Four plants per square foot are considered a minimum stand for canola. However, with herbicide-tolerant canola varieties, stands can be as low as two plants per square foot, providing weeds are controlled and plants are uniformly spaced with no large areas where canola is not growing.

Dormant Seeding

Dormant seeding of canola can be defined as seeding canola in cold, nearly frozen soil late enough in the fall to inhibit germination. 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. Research results have shown that fall seeding canola is a high-risk practice, especially in growing areas with variable winter temperatures and soils having a potential to dry out significantly during the winter.

Soil Fertility Requirements

Dave Franzen,
Extension Soil Science Specialist

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 = (YP X 0.065) STN - PCC

where NR = supplemental nitrogen recommended

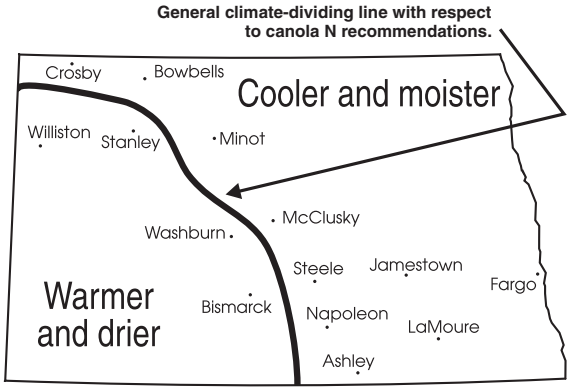
YP = yield potential in lb/a (pounds per acre)

STN = soil nitrate-N 0- to 24-inch depth

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

Nitrogen recommendations at selected yield potentials are shown in the table **"N, P and K recommendations,"** with an upper limit of 150 lb/a N for cooler, moister areas and 120 lb/a for warmer, drier areas. See the map below. Yield potential should be conservative, based on a five-year average and not on an optimistic yield such as what a wheat grower might produce.

Ammonium sources of N may be fall-applied on most North Dakota soils, except on sandy loam or coarser textures, or where flooding is expected in the spring. Spring application may be made preplant or at planting.



General climate map of North Dakota with respect to canola production. In any given year, the line separating cooler, moister areas from warmer, drier areas may move east or west considerably.

Canola is very sensitive to fertilizer salts. No more than 5 lb/a of N is recommended with the seed in 12-inch row spacings for medium-textured soils, but the rate can be increased proportionally with narrow row spacing or increase in seed spread *(see table **"Maximum rates of seed-placed N + K_2O for canola,"** page 20).*

Phosphorus (P) and Potassium (K)

P and K recommendations are shown in table ***"N, P and K recommendations,"*** *(page 19)*. Canola is a good scavenger of P, and a row-starter fertilizer rate of 20 to 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 because 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 final N + K_2O is 10 lb/a or lower, using a double disc opener with 12-inch row spacing *(see table **"Maximum rates of seed-placed N + K_2O for canola,"** page 20)*. Broadcasting P and K is acceptable. However, I recommend a small amount of P as a row starter in addition to any broadcast application.

N, P and K recommendations for canola.

Yield Potential	Soil N + Supplemental N	Olsen-P, ppm VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+	Soil test K, ppm. VL 0-40	L 41-80	M 81-120	H 121-160	VH 160+
lb/a	lb/a at 0-2 ft.	lb P_2O_5/a					lb K_2O/a				
1,500	100	49	36	23	9	0	70	50	30	10	0
1,850	120[1]	60	44	28	12	0	86	62	37	12	0
2,300	150[2]	75	55	35	15	0	95	77	46	15	0
3,000	150[2]	80	60	35	15	0	140	100	60	20	0

[1] Indicates cap for warmer and drier areas in the state.
[2] Indicates cap for cooler, moister areas in the state.

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

Soil Texture	Disc or Knife (1-inch spread) Row Spacing 6 in.	9 in.	12 in.	Spoon or Hoe (2-inch spread) Row Spacing 6 in.	9 in.	12 in.	Sweep (4- to 5-inch spread) Row Spacing 6 in.	9 in.	12 in.
	lbs N + K_2O /a								
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

Sulfur

Canola has a special requirement for sulfur. The consequences of low soil S levels are very serious in canola production. Yield increases due to sulfur application have been demonstrated in North Dakota (see response table). 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. Therefore, at medium to low sulfur soil tests, growers should apply 20 to 30 lb/a S. At high soil sulfur levels, the recommended rate is 10 to 15 lb/a S. Canola takes up sulfate-S. The form of sulfur fertilizer may be ammonium sulfate (21-0-0-24S) or other sulfate fertilizer, such as ammonium thiosulfate or potassium thiosulfate. Elemental sulfur forms have not performed well in regional trials.

Micronutrients

Canola yield has not responded to any micronutrient in North Dakota.

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

			Soil Types		
Rate	Source	Tillage	Buse	Barnes	Svea
lb S/acre			Yield in lb/a		
0		CT	400	1,020	1,180
20	AS	CT	1,810	1,980	1,860
40	AS	CT	1,890	1,670	1,980
40	ES	CT	1,260	1,290	1,470
0		NT	30	240	1,450
20	AS	NT	1,650	1,680	2,100
40	AS	NT	1,810	1,870	1,810
40	ES	NT	620	1,060	1,630

LSD 5% within tillage treatments 155 lb/a.

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 Management and Control

Richard Zollinger,
Extension Weed Specialist,
and
Brian Jenks,
Weed Scientist

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. Photographs of various weeds can be found in the back of this field guide.

- Some weeds are more competitive with canola than others. Canada thistle and wild oat 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 when wild oat was 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 Roundup Ready canola) and Stinger provide excellent Canada thistle control in canola. Consider a split application if Canada thistle densities are high (greater than one per foot^2) or emerge before or about the same time as canola.

- 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 them.

Weed Control Options for Canola

The following information provides general details regarding herbicide cost (2011), rate, weeds controlled, when to apply, etc. This information does not supersede 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 2011 growing season. Illegal herbicide use may result in condemnation of the crop and possible fines.

Sonalan (ethalfluralin)

$/a: 7 to 12

Rate: 5.5 to 9.5 lb 10G; 1.5 to 2.5 pt (pints) HFP (0.55 to 0.95 lb ai [active ingredient])

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

Treflan (generic trifluralin)

$/a: 3.25 to 9.50

Rate: 5 to 10 lb 10 G; 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 (generic clopyralid)

$/a: 15 to 30

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: Two- to six-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.

Ignite (glufosinate) – Liberty Link canola

$/a: 13.35 to 16.20

Rate: 22 fl oz (fluid ounces) (0.4 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 (ammonium sulfate) fertilizer at 3 lb/a. Ignite is a nonresidual, contact herbicide. Must apply to small grasses because Ignite only will suppress large grasses. May tank-mix with a half 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 Ignite with a grass herbicide. Ignite will not control perennial weeds. See label for optimum application timing to control broadleaves and grasses based on weed size.

Beyond (imazamox) – Clearfield canola

$/a: 19

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 to 2 gal [gallons]/100 gal) or nonionic surfactant (1 qt [quart]/100 gal) and nitrogen fertilizer (2.5 gal/100 gal). Beyond is weak on wild buckwheat and lambsquarters. Beyond will not control ALS (acetolactate synthase)-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 – Roundup Ready canola

$/a: 3 (does not include technology fee)

Rate: 0.375 to 0.56 lb ae [acid equivalent] (total of 0.75 lb ae can be applied from emergence to six-leaf stage)

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 one- to three-leaf canola followed by the second application at a minimum of 10 days but no later than the six-leaf stage. Allow an eight-week preharvest interval (PHI).

Assure II (quizalofop)

$/a: 8.15 to 11.35

Rate: 7 to 10 fl oz (0.77 to 1.1 oz ai)

Weeds: Annual grasses and quackgrass

Apply: Allow a 60-day PHI

Remarks: Controls grasses only. Use higher rates for yellow foxtail and quackgrass. Apply with crop oil concentrate at 1 percent v/v (volume to volume). Label indicates that 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 seven 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: 10 to 15.50

Rate: 1 to 1.5 pt (0.2 to 0.3 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 grasses are less than 4 inches. Apply with oil adjuvant at 1.25 to 2 pt/a. Add nitrogen to improve wild oat and volunteer cereal control (2.5 lb/a AMS or 4 pt/a UAN [urea-ammonium nitrate] solution). Poast is rain-fast one hour after application.

Rates required for different grass species are:

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

Select (generic clethodim)/
Select Max (clethodim plus adjuvants)

$/a: 4 to 5/10 to 17.50

Rate: 4 to 5 fl oz (1 to 1.25 oz ai) / 9 to 16 fl oz (1.125 to 2 oz ai)

Weeds: Annual grasses

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

Remarks: Do not apply after crop has begun bolting because crop injury may occur. Apply with oil adjuvant at 1.25 to 2 pt/a.

Rates required for different grass species are:

Barnyardgrass	1 to 4 inches	4/6 fl oz
Green foxtail	1 to 4 inches	4/9 fl oz
Yellow foxtail	1 to 4 inches	4/9 fl oz
Wild oat	1 to 4 inches	5/9 fl oz
Volunteer cereals	1 to 4 inches	5/9 fl oz

Preharvest herbicides for canola.

Reglone (diquat)*	**1.5 to 2 pt 2SL** (0.37 to 0.5 lb)	Desiccant	POST. Allow a 7-day PHI. Harvest no later than 10 days after application.	Add NIS at 0.25 percent v/v. Nonresidual, contact herbicide requiring thorough coverage. Most active in hot and sunny conditions. conditions. Maximum of 1 application per season. Apply when 60 to 70 percent of canola seed turns green to brown stage.

* Generic equivalent may have different label.

Relative Herbicide Effectiveness on Weeds and Persistence in Soil

A general rating for herbicide effectiveness on weeds and herbicide persistence in soil is provided in the table. 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 to 99 percent control
G: Good = 80 to 90 percent control
F: Fair = 65 to 80 percent control
P: Poor = 40 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.

Herbicide	Mode of Action	Barnyardgrass	Brome, Downy	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild Oat	Buckwheat, Wild	Cocklebur, Common	Horseweed (Marestail)	Kochia	Lambsquarters	Lanceleaf Sage	Mallow, Common	Marshelder	Mustard, Wild	Mustard, W. Annual	Nightshade, E/Black	Nightshade, Hairy	Pigweed, Redroot	Pigweed/Waterhemp	Prickly Lettuce	Ragweed, Common	Smartweed, Annual	Sunflower	Thistle, Russian	Wormwood, Biennial	Thistle, Canada	Herb. Persistance
Sonalan (PPI)	3	E	F-G	E[1]	E	N	P	P	P	P	N	P-F	E	N	-	N	N	P	P	N	E	G-E	P	N	P	N	G-E	N	N	S
Treflan* (PPI)	3	E	F-G	E[1]	E	N	P	P-F	P	N	N	P	G-E	N	-	N	N	P	N	N	E	G-E	N	N	P	N	G	N	N	S
Stinger	4	N	N	N	N	N	N	N	F-G	N	P	F-G	F	N	F-G	E	N	P	E	E	P	P	E	G-E	G-E	P-F	E	E	E	S
Assure II/Targa	1	E	P-E	E	F-G	E	E	G-E[1]	N	N	G-E	N	P-F	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Poast	1	E	P-G	E	E	F	G-E	G-E[1]	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Select*	1	E	P-E	E	E	G	E	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Select Max	1	E	P-E	E	E	G-E	E	E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Herbicide-resistant Canola																														
Beyond	2	E	G-E	E	G-E	F	G-E	E[1]	P	G-E	P[1]	E[1]	F	E	P	G-E	E	E	E	E	E	P-G[1]	E[1]	P	G-E	E	N-P	P	G-E	S
Ignite 280	10	E	-	E	G	P	F-G	G-E	E	E	E	F	F-G	E	G	E	E	G-E	G-E	E	F-G	G-E	E	G-E	E	E	G-E	E	P	N
Roundup*/ Glyphosate[2]	9	E	G-E	E	E	E	E	G-E	P-G	E	G-E[1]	F-E[1]	P-E[1]	E	P-G	G-E	G-E	P-G	P-G	E	P-G	P-G[1]	P-G	G-E[1]	P-E	G-E	G	F-E	G-E	N

PPI = Preplant Incorporated.
*Or generic equivalent.
[1]Herbicides will not control resistant biotypes or provide minimal control in tank-mix/premixes with alternative modes of action.
[2]Weed control from Roundup® is dependent on rate, size of weeds, environmental conditions and number of applications.

Rotation restrictions for planting canola.

Herbicide	Months after application	Herbicide	Months after application
Accent* (<0.68 oz DF/a)	18	**Milestone**	24b
Ally*	34cd	**Nortron**	12
Ally Extra* (0.2 oz)	22e	**Olympus**	22k
Amber	B	**Paramount**	10
Assert	12/15f	**Permit/Sandea**	15
Atrazine* (0.38 lb ai)	NCS	**Plateau**	48b
Atrazine* (0.38-0.5 lb ai)	2CS	**PowerFlex**	9
Atrazine* (0.5-1 lb ai)	2CS	**PrePare**	9
Authority Assist	40b	**Prequel**	18
Authority First/Sonic	24	**Prowl EC/H2O**	NCS
Authority MTZ	24	**Pulsar**	9
Axial TBC	9	**Pursuit**	40b
Balance Flexx	18j	**Pursuit Plus**	40b
Banvel* (<1.5 pt)	4h	**Python**	26b
Beyond	18	**Raptor/Beyond**	18
Boundary	12	**Raze**	9
Callisto	NCS	**Reflex**	18
Callisto Xtra	NCS	**Require Q**	10j
Camix	18	Resolve*(<1.1 oz DF/a)	10j
ClearMax	18	**Resolve Q**	10j
Curtail*/M*	5	**Rimfire Max**	10
Everest 2.0	9	Sencor*	12u
Extreme	40b	**Sharpen (1 fl oz)**	4v
Far-Go	NCS	**Sharpen (2 fl oz)**	5v
Fierce	18	**Sharpen (3 fl oz)**	6v
FirstRate	30b	**Sonalan**	0
Flexstar/GT	18	**Spartan**	24
Gangster	B	**Spartan Advance**	24
Glean*	B	**Spartan Charge**	24
Goldsky	9	**Starane Flex**	9
Halex GT	10	**Status**	4h
Harness*	NCS	**Steadfast (<0.76 oz/a)**	18
Hornet	26b	Stinger*	0
Huskie	9	**SureStart/TripleFlex**	26b
Ignite 280	0	Surpass*	NCS
Impact	9	**Tordon (1.5 oz)**	2CS
Laudis	10	Treflan*	0
Lightning	40b	**Valor/Chateau**	-
Lumax (<3 pt/a)	18	WideMatch*	4
Matrix*	18	**Wolverine**	9
Maverick	B		

continued

* Or generic equivalent.

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

b = Bioassay. Do not plant until field bioassay indicates it is safe.

c = Do not use on soil with pH greater than 7.9.

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

e = Requires soil pH of 7.9 or less, 22 months and 22 inches of precipitation west of North Dakota Highway 1 or 34 months and 34 inches of precipitation east of Highway 1. These restrictions also apply to Ally Extra* at rates greater than 0.2 oz dry fowable (DF)/a.

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

h = Any rotational crop may be planted 120 days following application of Banvel* at 1.5 pt/a or less, excluding days when ground is frozen. For all crops and rates greater than 1.5 pt/a, allow 45 days per 1 pt/a of Banvel* using excluding days when ground is frozen.

j = Requires 15 inches of cumulative precipitation during the growing season following application. An 18-month restriction applies to Accent*, Resolve*, Prequel and Steadfast applied above rates indicated or if drought follows application. Refer to label for crop rotation restrictions if rates greater than those indicated are used.

k = Requires 24 inches of accumulated precipitation.

u = Must add two months if soil is frozen.

v = Do not include time when soil is frozen. For Verdict: All crops can be planted the spring following application.

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

Herbicide	Time Interval
Assure II	1 hour
Beyond	1 hour
Glyphosate (Full adj.)	6-12 hours
Glyphosate (Part. adj.)	6-12 hours
Glyphosate (No adj.)	6-12 hours
Ignite	4 hours
Poast	1 hours
Select/SelectMax	1 hour
Stinger	6-8 hours

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 harvest operations to minimize canola seed losses. Following the 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 secondary dormancy is more likely to be induced. If practical, allow time in the spring for canola volunteers to germinate before a tillage operation and then till and seed the new crop as soon as possible.

For no-till small grains, consider adding a labeled herbicide to the glyphosate burn-down 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. Some herbicides 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. All postemergence herbicides were applied with recommended adjuvants. 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 to 99 percent control
- G: Good = 80 to 90 percent control
- F: Fair = 65 to 80 percent control
- P: Poor = 40 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 (2011). 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

Herbicide	Rate	Pre-Cost	3-leaf emergence	6-leaf canola	Bolting canola	Flowering canola	canola
	product/a	$/a	Control rating				
IN CORN							
Accent	0.5 oz	16.90	—	E	E	—	—
Atrazine	0.75 pt	1.80	G	G	P	—	—
Balance Flexx	3 fl oz	13.50	E	—	—	—	—
Callisto	3 fl oz	15.00	E	E	G-E	—	—
Laudis	3 fl oz	15.00	—	E	G-E	—	—
Option	1.5 oz	15.00	—	E	E	—	—
Starane	0.5 pt	5.30	—	VP	VP	—	—
Status	4 oz	11.00	—	G	F	—	—
Steadfast	0.75 oz	20.00	—	E	E	—	—
2,4-D Amine	0.5 pt	1.00	—	G	P	—	—
IN SOYBEAN							
Basagran	0.5 pt	6.25	—	G-E	F	—	—
Cobra	6 fl oz	8.00	—	G-E	VP	—	—
Extreme	1.5 pt	9.40	E	E	G-E	P	P
FirstRate	0.3 oz	10.00	E	E	F-E	P-F	F
Flexstar	0.75 pt	11.50	E	E	E	E	E
Harmony	0.083 oz	1.50	—	P-F	P	—	—

Pursuit	2 fl oz.	12.00	G-E	E	G-E	P	P
Python	1 oz	12.00	F-G	—	—	—	—
Raptor	4 fl oz	19.50	—	E	E	G	F
Sencor	0.25 lb	4.00	E	G-E	F	—	—
Spartan	4 fl oz	17.00	P-F	—	—	—	—
Ultra Blazer	0.75 pt	6.75	—	F-G	P	—	—
Valor	2.5 oz	12.00	G-E	—	—	—	—
IN DRY PEA							
Basagran	0.5 pt	6.25	—	G-E	F	—	—
Pursuit	2 fl oz	12.00	G-E	E	G-E	P	P
Raptor	4 fl oz	19.50	—	E	E	G	F
Metribuzin	0.25 lb	4.00	E	G-E	F	—	—
Spartan	4 fl oz	17.00	P-F	—	—	—	—
IN SUNFLOWER							
Assert	0.8 pt	7.50	—	E	G	—	—
Spartan	4 fl oz	17.00	P-F	—	—	—	—
IN FLAX							
Bronate Adv	0.8 pt	6.20	—	E	F-G	—	—
MCPA ester	0.5 pt	1.50	P	G-E	P	—	—
Spartan	4 fl oz	17.00	P-F	—	—	—	—

continued

Volunteer canola control

Herbicide	Rate	Pre-Cost	3-leaf emergence	6-leaf canola	Bolting canola	Flowering canola	canola
	product/a	$/a	Control rating				
IN WHEAT							
Aim	0.5 oz	3.50	—	VP	N	N	N
Bronate Adv	0.8 pt	6.20	—	E	F-G	—	—
Curtail	0.5 pt	3.25	—	G-E	F-G	—	—
2,4-D ester	0.5 pt	1.25	—	G	P	—	—
Dicamba	2 fl oz	1.00	—	P	N	N	N
Express	0.167 oz	2.90	—	E	G-E	—	—
Harmony	0.3 oz	2.40	—	E	G-E	—	—
Huskie	11 fl oz	7.75	—	E	G-E	—	—
MCPA ester	0.5 pt	1.50	P	G-E	P	—	—
Sharpen	1 fl oz	4.70	E	E	E	F	G
Starane	0.5 pt	3.75	—	VP	VP	—	—
WideMatch	0.25 pt	3.00	—	P	P	N	N
Wolverine	1.7 pt	20.00	—	E	G-E	—	—

Insect Management and Control

Janet J. Knodel,
Extension Entomologist,
and
Pat Beauzay,
Entomologist

Photographs of various insects
can be found in the back of this field guide.

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 Beetle
***(Phyllotreta cruciferae)* and**

Striped Flea Beetle
(P. striolata)

Coleoptera: Chrysomelidae

The crucifer flea beetle has a single generation per year. The striped flea beetle also feeds on canola in North Dakota. Adult flea beetles overwinter in shelterbelts and leaf litter near last year's canola fields. Adults start to emerge as temperatures warm to 58 F. 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 flea beetles are about 1/10 inch long with a metallic bluish sheen. They move into the canola fields just as the seedlings are emerging. Adults feed on the cotyledons and first true leaves of seedlings and cause 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 roots 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 populations of the summer generation often indicate that flea beetle pressure may be high the following spring.

Pest Management

Insecticides are the most effective control measure for flea beetles. The seedling stage is the most susceptible period, and insecticides need to be applied either 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, seedlings should be protected from flea beetle feeding for most of the susceptible seedling stage. Seed treatments usually provide three to four weeks of protection against flea beetles.

Adult flea beetles emerge during 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 high flea beetle populations. Producers should inspect seedling fields daily for flea beetle injury. Check several locations in the field (for example, edges and center). Warm (greater than 58 F), calm, sunny weather increases feeding activity and movement, while cool, windy, 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 also may 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. **Foliar insecticide applications are recommended 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 reinfestation from surrounding areas. Foliar applications must be applied quickly for effective control. One of the problems producers face is not being able to cover a large acreage quickly when flea beetle populations are 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 migratory diamondback moth usually arrives in late May or early June in North Dakota. The complete life cycle takes about 32 days from egg to adult. It has several generations 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, and drab brown. At rest, the forewings of the male moth form three diamonds; hence the name diamondback moth. 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, the green outer layer of the stems and, occasionally, the developing seeds. The amount of damage will depend on the crop stage and larval density and size. Extensive feeding on the flowers will delay plant maturity and cause flowers to abort and the crop to develop unevenly, resulting in reduced seed yield. As leaves wilt and drop in late July to early August, larvae will feed on the stem, pods and developing seeds. Damaged pods will not fill completely and may shatter. Severely damaged pods appear whitish in contrast to the normal yellowing and browning of ripening undamaged 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 trap with sticky inserts used to capture moths. Traps should be suspended near the crop at the field's edge. Traps provide an early indication of a possible infestation. **This insect usually has two to three generations in North**

Dakota. The second generation is the most important because it usually is present when the crop is most susceptible to damage (blooming to early pod). The third generation usually is too late to damage most canola, except for the very late-planted fields.

If high numbers of adults (greater than 100 moths per trap week) are being captured in the traps during bloom to early pod development, monitor fields for diamondback moth larvae by beating plants to dislodge the larvae from the plants. After beating the plants, count larvae on the ground or dangling from the plants on a silk thread. Again, check several locations per field. **The action threshold for canola at the pod stage is about 20 larvae 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).** The best pest management strategies to avoid yield losses from diamondback moth include early monitoring of adults and larvae, and judicious use of insecticides only when fields are above thresholds. A number of natural factors also can affect diamondback moth populations negatively. For example, heavy rainfalls can drown many first-generation larvae. 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 diamondback moth larvae.

Bertha Armyworm
(Mamestra configurata)
Lepidoptera: Noctuidae

The adult moth is about 1½ inches long, mainly gray-black with a silvery-whitish kidney-shaped spot and with a 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 honeycomblike clusters of 50 to 500 eggs, which hatch in about one week. The emerging larvae (1/10 inch) are usually green. Mature larvae are about 1½ inches long and vary from green to 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. This insect has only one generation per year.

As the canola plant drops its leaves, the mature larvae (greater than ½ inch) begin to feed directly on the pods, which causes economically important yield losses and premature shattering. Feeding injury by the mature larvae also accounts for 80 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 due to 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 that follow. Fields should be monitored about two weeks after 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 will range from one to three larvae per square foot.** Higher-priced canola will require fewer larvae to reach the economic threshold. The key to controlling bertha armyworm is:

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

Lygus Bugs
(Lygus species)

Hemiptera: Miridae

Lygus bugs consist 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 the 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. Nymphs are small, green and sometimes confused with aphids, although Lygus nymphs are very active and move rapidly when disturbed, while aphids do not. Several generations occur each year, with the second generation occurring 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 mouthparts 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 seeds 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 bugs 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 bugs per 10 sweeps during bud stage through petal fall, and 20 Lygus bugs per 10 sweeps after petal fall and through pod ripening.** However, if populations are large, control during the early pod ripening stage usually is the most economical.

Cutworms

Lepidoptera: Noctuidae

Several species of cutworms such as dingy cutworm, red-backed cutworm and pale western cutworm, create problems for agricultural crops in the northern Great Plains. Adult cutworms are moths, have dark wing colors (brown to gray) with markings and wings about 1½ inches long. Cutworms have one generation per year. They overwinter as eggs or young larvae, depending on the species. Species that overwinter as 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 1½ 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 pupa in August to early September. Adults mate and lay eggs on or just below the surface of loose, dry soil; weedy stubble; or fallow fields, depending on the species.

Cutworm damage first appears on hilltops or south-facing slopes, or in areas of light soil, which warm earlier in the spring. Larvae will cut young canola plants in the seedling to rosette stages. Cut plants can be found drying 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 or hide under soil debris. 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 justifies an insecticide treatment.** Cutworm larvae are feeding actively at night, so an evening insecticide 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. Grasshoppers overwinter as eggs, and nymphs start to hatch and emerge from the soil in late April to early May, with peak egg hatch in mid-June. Nymphs (young grasshoppers) will go through five molts before transforming into adults. 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. Adults and nymphs feed on green plant material with their chewing mouthparts, 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 diseases that infect and kill grasshoppers. Scout canola for feeding injury from nymphs in the seedling stage and from adults in the pod development stage. 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 can estimate numbers for 1 square yard.

The infestation ratings are listed below in the table. A "threatening" rating would indicate a need to treat with an insecticide.

Ratings for grasshopper nymphs and adults.

	Nymphs 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 blister beetle species 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 blister beetle species have one generation per year. Adults become active in early to midsummer and lay eggs in the soil. Eggs hatch in about two weeks into larvae called triungulins, which actively prey on grasshopper egg pods (*Epicauta* spp.) or bee nests (*Lytta* spp.). Blister beetles overwinter as larvae. Adult blister beetles are attracted to blooming canola fields, where they are ravenous feeders, devouring leaves, stems, flowers and pods. Blister beetles are mobile and gregarious, and often congregate in certain spots in a field. In some instances, blister beetles feed for a short period of time and then migrate to other plants

or fields. Alfalfa is an alternative host of blister beetles, and they often move into canola fields when the alfalfa is cut. Blister beetles produce an extremely poisonous toxin (cantharidin) if ingested by horses and to a lesser degree by other livestock (sheep and beef cattle).

Pest Management

The presence of large numbers of blister beetles in spots of a canola field often has concerned producers. However, adult feeding generally is not significant enough to warrant an insecticide treatment. **The "High Plains Integrated Pest Management Guide" recommends treatment when fields have 10 adult blister beetles per plant feeding on the flowers or pods.** However, no economic threshold has been set in North Dakota. Spot treatment with foliar insecticides registered in canola is recommended.

Aphids (Cabbage Aphids, Turnip Aphid, and Green Peach Aphid)

Hemiptera: 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 to 4 millimeters 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 excrete.

Many aphids migrate into North Dakota from southern states; some species do overwinter in the region. Migrating aphids begin to arrive in late spring to first colonize canola. As a result, late-planted canola may be more susceptible to heavy aphid infestations. Females reproduce asexually and give birth to live young within seven days. As aphid populations build and become crowded, winged adults are produced and they disperse to begin new colonies. Multiple, overlapping generations of aphids occur within a season. Aphids suck out 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, **control may be justified when at least 20 percent of the stems are infested with a cluster of aphids in the 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 when the following conditions are met: 1) canola was planted late; 2) plants are still in pod development; and 3) low populations of natural enemies, such as lady beetles, syrphid flies or lacewings, are present.

Insecticides labeled for canola insect pests in North Dakota (sorted by insecticide class and active ingredient).

Insecticide Class	Active Ingredient	Product1	Preharvest Interval (days)	Targeted Insects
insect growth regulator	tebufenozide	Confirm 2F	14	bertha armyworm
microbial	*Bacillus thuringiensis*	Dipel DF	None	bertha armyworm
neonicotinoid	clothianidin	Poncho or Prosper (insecticide plus fungicide premix). *For commercial seed treaters only.* NipsIT Inside. *For seed treatment by commercial seed treatment equipment only.*	—	flea beetles
	imidacloprid seed treatment	Gaucho 600, Attendant 600, Dyna-Shield Imidacloprid 5, Senator 600, and generics. *For commercial seed treaters only.*	—	flea beetles
	thiamethoxam seed treatment	Helix (10.3% active) and Helix Xtra (20.7% active). *For commercial seed treaters only.*	—	flea beetles

organophosphate	methyl parathion	Methyl parathion*	28	diamondback moths, flea beetles
pyrethroid	bifenthrin	Bifenture 2E*, Brigade 2E*, Fanfare 2EC*, Tundra EC*, and generics	35	bertha armyworms, cutworms, diamondback moths, flea beetles, grasshoppers, Lygus bugs
	deltamethrin	Delta Gold*	7	bertha armyworms, cutworms, diamondback moths, flea beetles, grasshoppers, Lygus bugs
	gamma-cyhalothin	Proaxis*	7	bertha armyworms, cutworms, diamondback moths, flea beetles, grasshoppers, Lygus bugs
	lambda-cyhalothrin	Warrior II*, Silencer*, Grizzly Z*, Kaiso 24 WG*, Lambda-Cy* and generics	7	bertha armyworms, cutworms, diamondback moths, flea beetles, grasshoppers, Lygus bugs
	zeta-cypermethrin	Mustang Max EC*	7	bertha armyworms, cutworms, diamondback moths, flea beetles, grasshoppers, Lygus bugs

*Restricted-use insecticide

1Always read and follow the manufacturer's directions before using the product and always use the labeled rates. Please consult the current edition of the "North Dakota Field Crop Insect Management Guide," NDSU Extension Service publication E-1143 (*www.ag.ndsu.edu/pubs/plantsci/pests/e1143w1.htm*), for more information and restrictions on insecticides labeled for canola.

Follow safe pesticides practices when spraying flowering canola to protect honey bees and native pollinators. If spraying canola during bloom is necessary, apply insecticide during early morning or late evening hours when bee foraging activity is minimal and bees are back at the hive. Be sure to notify local beekeepers before the insecticide application.

Disease Management and Control

Sam Markell,
Extension Plant Pathologist,
Luis del Rio Mendoza,
Research Plant Pathologist,
and
Michael Wunsch,
Extension Plant Pathologist

Two main diseases impact canola production in North Dakota: blackleg and sclerotinia stem rot. This section will focus heavily on those diseases and discuss others briefly. Photographs of various diseases can be found in the back of this field guide.

Blackleg

Cause

Blackleg is caused by two fungal pathogens, *Leptosphaeria maculans* and *L. biglobosa*. *L. maculans*, which is highly aggressive, is the predominant cause of blackleg in North Dakota and Minnesota. It consists of several pathogenicity groups (PGs) that differ in their virulence to specific canola varieties; to date, four pathogenicity groups have been identified: PG1, PG3, PG4, and PGT. *L. biglobosa* previously was considered a mild strain of *L. maculans*; in the 1990s, it was referred to as PG2 of *L. maculans*. Today it is recognized as a distinct species. *L. biglobosa* is less

damaging than *L. maculans*, and it is found in North Dakota and Minnesota infrequently.

Signs and Symptoms

Infection by the blackleg pathogen often is observed first on leaves. Round to irregular-shaped lesions with a tan or buffed color appear as early as the seedling stage but can occur anytime until crop maturity. Leaf spots enlarge, and small black fruiting bodies called "pycnidia" are formed in the center of the lesions. Pycnidia are small but visible to the unaided eye and resemble ground black pepper flakes in color and size.

Stems are most susceptible to infection before they reach the four- to six-leaf stage. Lesions can occur anywhere on the stem, but often they are found near the base of the stem where a leaf was attached. Stem lesions are gray to dark gray and are surrounded by a dark or black border. Pycnidia frequently are produced in the center of stem lesions. Lesions become sunken and may rupture and girdle the stem, producing the characteristic "blackleg" symptom. Infected stems also exhibit internal discoloration; when split open, the internal tissues of infected stems frequently are black, gray or stained with gray streaks. Early infection of the stem may result in premature senescence and lodging. Late stem infection can cause plants to be less vigorous but otherwise causes few above-ground symptoms.

Roots, pods and seeds also are susceptible to infection. Infected roots develop internal discoloration; when split open, internal tissues will be black, gray or stained

with gray streaks. Root infection causes premature senescence and yield loss but is not always associated with other above-ground symptoms. Infected pods may split open, resulting in seed loss, and seed produced in infected pods may be gray and shriveled.

Survival and Spread

The blackleg pathogen survives for several years on infected crop residue. In the spring, the blackleg pathogen forms fruiting structures on this residue. These fruiting structures produce sexual spores (ascospores), which can be dispersed to new canola plants and cause infection. Ascospores can be dispersed for several miles, but most are deposited much closer to the source. Maximum ascospore discharge occurs the year following a canola crop but can occur until residue is degraded completely.

Infection by ascospores results in the development of blackleg. On diseased tissues, the blackleg pathogen produces abundant pycnidia (asexual fruiting structures); during wet weather, pycnidia release a gelatinous ooze containing pink asexual spores (conidia) that are dispersed by rain. The conidia are responsible for localized spread of the blackleg fungus, resulting in "hot spots" of infection.

Temperatures in the 70s F and extended periods of canopy wetness favor infection. Disease development is inhibited by temperatures above 85 F or below 50 F. Plant injury (from insects, hail, herbicides, etc.) can increase the incidence and severity of blackleg.

The blackleg pathogen can survive for several years in infected seed. When infected seed is planted, seedlings emerge and develop cotyledon, leaf and stem infections. Infections from seed can result in early and widespread epidemics. Transport of infected seed to other regions has contributed to the spread of blackleg throughout the world.

Management

Resistance – Host resistance is one of the most effective and least expensive management tools for this disease. We recommend that producers plant a resistant hybrid. However, hybrids marketed as resistant to blackleg carry resistance to only one strain of the blackleg pathogen, PG1; they are susceptible to the other strains of the blackleg pathogen: PG3, PG4, and PGT. In a greenhouse study conducted at NDSU in 2010, 73 commercial hybrids were screened for resistance to blackleg and none was resistant to PG groups PG3, PG4, and PGT. PG3, PG4, and PGT have been identified in North Dakota, and growers affected by these strains of the blackleg pathogen should recognize that resistant (PG1) hybrids will not confer protection against these new strains. Efforts to breed resistance are underway, and resistant hybrids to the other PGs may be available in the future.

Hybrid Rotation – Rotating hybrids may slow the development of new strains (pathogenicity groups) of the pathogen by reducing selection pressure on the pathogen. If severe blackleg is observed, a different hybrid should be used in the future.

Crop Rotation – Because the blackleg pathogen survives in crop residue for multiple years, we recommend a four-year crop rotation. In addition to reducing disease pressure, a longer crop rotation will reduce the likelihood that new pathogenicity groups are formed.

Disease-free Seed – Plant certified disease-free seed. This is especially important when planting canola into a new area.

Seed Treatment Fungicides – Numerous fungicide seed treatments are registered for blackleg in North Dakota. Make sure to use a seed treatment that is effective against blackleg. Metalaxyl alone will not control blackleg. Consult the most recent issue of the "North Dakota Field Crop Fungicide Guide" (Extension publication PP-622) when selecting a fungicide seed treatment.

Foliar Fungicides – Take economics and disease risk into consideration before applying a foliar fungicide. High-risk factors include a susceptible or moderately susceptible variety, the known occurrence of one of the new pathogenicity groups of the blackleg pathogen (PG3, PG4, or PGT), or a tight crop rotation. Fungicide trials conducted in 2004 and 2005 demonstrated that a single fungicide application was able to reduce disease and provide some yield protection in susceptible varieties but that foliar fungicides did not give adequate control as a single management strategy. If utilized, foliar fungicides should be applied at the two- to four-leaf stage.

61

Consult the "North Dakota Field Crop Fungicide Guide" (Extension publication PP-622) for available products and always follow label directions.

Control Weed Hosts – Volunteer canola and wild mustard are hosts to the disease and should be controlled in crops rotated with canola.

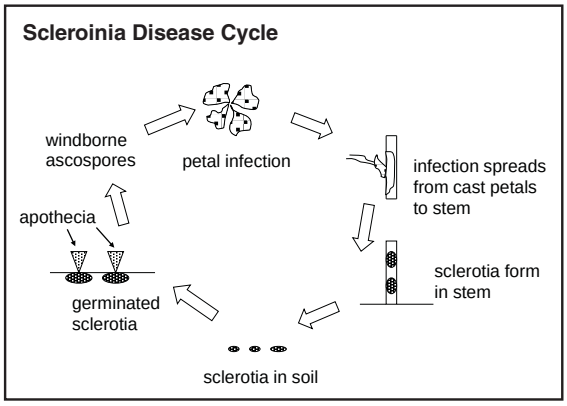
Resources and Citations

This information was adapted from publication PP-1367, "Blackleg of Canola," and additional information and photographs can be found in that publication. Fungicide information can be found in publication PP-622, "Field Crop Fungicide Guide."

Sclerotinia Stem Rot (SSR)

SSR is one of the most serious and common diseases of canola in North Dakota. Average statewide yield losses in North Dakota and Minnesota have reached 13 percent, with losses in some fields as high as 50 percent. SSR occurs almost every year and in most regions of the state. However, in recent years, new management tools, including a forecasting model to aid in fungicide decision making, have become available. Additionally, multiple fungicides are labeled, giving canola producers options that were not accessible a couple of years ago.

62



Cause

The fungal pathogen *Sclerotinia sclerotiorum* causes disease in more than 400 different plant species, including canola, dry beans, soybeans, sunflowers, flax and the pulse crops (peas, lentils, chickpeas).

Symptoms and Signs

Symptoms on canola plants do not appear until after flowering. Spores of *S. sclerotivorum* colonize dead flower petals, and the first visible symptom of SSR is a mushy, light brown target pattern on and around cast petals (colored parts of the flower). Cast flower petals accumulate in the junctions where leaf petioles join the stem. When one or more of these petals become infected with Sclerotinia, the infection spreads into the leaf petioles (slender stalk connecting the leaf to the plant), branches and stems. Infected

areas become bleached, taking on the appearance of dry bone, and they frequently become brittle and shredded. If infection occurs in the main stem, plants may die early and become prone to lodging. Standing dead plants may be visible in fields with severe SSR infection. After infection is well-established, hard, black structures (sclerotia), which resemble rat droppings, may be produced in infected tissues. The sclerotia are the survival structures of the pathogen and, although they are not produced in every infection, they are a definitive sign of SSR.

Survival and Spread

The pathogen produces sclerotia (resting structures) in infected stems. Sclerotia fall to the ground during harvest, and they can survive on or in the soil for many years. After the sclerotia have overwintered, 1 to 2 inches of rain in a one- to two-week period will moisten soil enough for sclerotia to germinate and produce small mushroom structures (0.1 to 0.25 inch diameter) called apothecia. If rain does not occur prior to flowering, the soil will be too dry for sclerotia to germinate, no apothecia and spores will be produced, and infection will not take place. Sclerotia must be in the top 1 to 2 inches of the soil profile to form apothecia; otherwise, they will remain dormant. Apothecia can produce millions of spores (ascospores) that are dispersed by wind; however, most ascospores remain trapped in the canopy near the apothecia. The great majority of spores do not travel more than 150 feet, but some spores will be disbursed

significantly farther when the right conditions persist. Spores can infect floral parts directly, but most infections occur when spores land on dead or dying tissue. Canola petals that die after flowering provide an excellent food source for the SSR spores, and most SSR disease lesions are initiated from infected dead flower petals. If spores are produced, the canopy must be wet for 40 to 48 hours for the spores to germinate and for infection to take place. However, even when ample moisture is available, if temperatures are too hot during this time (above 86 F), spores may die before they can begin to grow. If infection occurs, disease development will not occur above 86 F, but it will resume once cooler temperatures return. Similarly, if weather becomes dry, disease progression will slow and increase only when the canopy becomes wet.

Management

Crop Rotation – Crop rotation is important to limit the buildup of sclerotia. Try to avoid more than one highly susceptible crop (sunflower, canola, crambe, dry bean, pea or soybean) in a rotation. Semileafless peas support less buildup of sclerotinia than the vining types and may be acceptable in crop rotations. In irrigated trials at Carrington, N.D., no sclerotia were produced in flax; therefore, flax may be a relatively safe crop in rotation with canola. Additionally, corn and small grains are not susceptible to SSR.

A preferred rotation would have canola planted after two or more nonsusceptible crops. Despite appropriate crop rotation, some sclerotia can survive for long periods of time and can germinate and cause infection many years after they were produced. Additionally, infection can occur from spores blown in from other fields.

Tillage – Management of SSR with tillage is uncertain. Deep tillage may bury sclerotia deep enough that they do not produce apothecia. However, some data indicate that these sclerotia do not break down as fast as those near the surface and may result in infection if they are brought back near the surface later. Additionally, even if deep tillage is done, it probably is of limited value if used on one or a few fields and not areawide.

Resistance – All canola varieties are susceptible to some degree. However, some varieties may be less susceptible than others.

Biological Control – The fungus *Coniothyrium minitans* can attack and kill sclerotia in the soil. The fungus is sold commercially as Contans WG. Use of this fungus to battle sclerotinia is relatively new, and limited data exists on its efficacy. Contans may be of greatest use under high disease pressure rotations or cropping practices (such as irrigation). Other biocontrol products are entering the market; consult the most current "North Dakota Field Crop Fungicide Guide," PP-622, for more information.

Fungicides – Numerous fungicides are available, and new products likely will be available in the future. To find products available, consult the most current "North Dakota Field Crop Fungicide Guide," PP-622. Fungicide trials are done frequently at NDSU's Research Extension Centers in Carrington, Langdon and Minot (North Central REC). For the most current information, visit their websites at *www.ag.ndsu.edu/research/recenthp.htm*.

Fungicide Decision Making

Making the decision to apply (or not to apply) fungicides and spraying at the most appropriate growth stage are the two keys to managing SSR. Several resources can be used when determining whether a fungicide application is warranted, including the ***Sclerotinia Risk Map*** and the ***Sclerotinia Stem Rot Checklist***. In general, spraying is most beneficial when:

- One to 2 inches (or more) of rain occurred in the two weeks prior to flowering.
- Rain or high humidity is expected.
- Sclerotinia has been a problem in recent years.

Sclerotinia Risk Map – Environmental information generated from the North Dakota Agricultural Weather Network (NDAWN) weather stations are used to determine if conditions are favorable for the germination of sclerotia, development of apothecia and spore release. This information is used to generate a map with color-coded indications of risk throughout North Dakota and the canola-growing areas in Minnesota.

The map is an effective tool to help growers assess their risk of SSR infection. However, producers should keep several things in mind:

- The risk map only applies to you when your canola is flowering. Because the pathogen uses petals as a food source, no infection occurs prior to flowering.
- The map is meant as a *regional* guide to risk. The Risk Map is only as good as the information source, and even though NDAWN has approximately 67 weather stations, the environmental conditions in your field may be different. If you know you have had more/less rain than the NDAWN stations nearest you, your risk may be higher or lower.
- The Sclerotinia Risk Map calculates the likelihood of sclerotia germinating and, thus, spores being available to cause infection. Your fields may have greater or less risk, depending on other management techniques (crop rotation, less susceptible variety), field history and weather forecasts (for example, rain, high humidity, temperatures).

The map is available at *www.northerncanola.com* and *www.ag.ndsu.edu/sclerotinia/*.

Resources and Citations

This information was adapted from publication PP-1410, "Sclerotinia of Canola," and additional information and photographs can be found in that publication. Fungicide information can be found in publication PP-622, "Field Crop Fungicide Guide."

Sclerotinia Stem Rot Checklist

Reproduced from the Canola Council of Canada website 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 .....20 Moderately.....10 Lightly.....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.....20 No difference.....0

Total points for section one = _____

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 .....0 Moderately likely .....10 Not likely.....20

Total points for section two = _____

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.....20 Good.....10 Fair .....5 Poor.....0
13. When you walk through your crop, how dense is the canopy?	Light.....0 Moderate .....10 Very dense 20
14. What is the yield potential of the stand?	10-20 bu/a .....0 20-30 bu/a .....10 Greater than 30 bu/a 20
15. In previous years, when your yield potential was 30+ bu/a, what were the actual yields?	Greater than 30 bu/a .....0 20-30 bu/a 20

Total points for section three = _____

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

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

Alternaria Black Spot

Cause

Alternaria brassicae and Alternaria japonica

Signs and Symptoms

Spots may develop at flowering on the leaves. These spots may be gray, gray with a dark border or black. Leaf spots often are surrounded by a yellowish halo. 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 shattering of seed.

Survival and Spread

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, disease-free, germination-tested seed that has been cleaned properly. Most seed treatment fungicides effective against blackleg also will help control seed-borne black spot. Use well-balanced fertilizer applications because 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.

White Rust (Staghead)

Cause

Albugo candida

Signs and Symptoms

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 initially are green but later turn 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 during combining, resulting in the release of the spores. The following spring, these thick-walled spores germinate and infect the cotyledons and leaves of young plants. Secondary spread from cotyledons and leaves 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 because the fungus can reproduce on the cotyledons and young leaves.

Downy Mildew

Cause

Peronospora parasitica

Signs and Symptoms

A white, mealy growth develops on the lower surfaces of leaves as well as on the green stagheads caused by the white rust fungus. The upper leaf surface opposite the infected area turns yellow.

Survival and Spread

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

Disease Management

Downy mildew rarely is observed and has not been of economic concern in North Dakota. When disease is observed, it often is found on young seedlings in densely planted fields when conditions are very wet. As seedlings grow or temperatures rise, the disease usually disappears.

Clubroot

Clubroot is a destructive disease of many crops in the cabbage family. In 2003, it was detected in Alberta, Canada, where it has become a serious threat to canola production. It subsequently has been detected in western Saskatchewan. It has not been reported in North Dakota.

Cause

Plasmodiophora brassicae

Signs and Symptoms

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 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. The disease is spread by cultivating equipment moving soil from field to field.

Disease Management

No satisfactory management exists. Alkaline soils are less conducive to clubroot than acidic soils. In acidic soils, liming may reduce severity. Avoid introducing soil from infested areas. In Alberta, the primary mechanism of spread has been through infested soil carried on farming equipment. The clubroot pathogen is known to occur in British Columbia, Alberta, parts of Saskatchewan, Wisconsin, the Pacific Northwest, and eastern U.S. and Canada. Farm equipment obtained from those regions should be sanitized before use in North Dakota. The clubroot pathogen also causes disease on broccoli, cauliflower, cabbage and other Brassica species, so use caution when using transplants originating in these regions in gardens.

Aster Yellows

Signs and Symptoms

Distorted and sterile flowers are formed. Flowering portions of the plant may show excessive branching and stunting (shortened internodes), resulting in a "witches broom" appearance. Pods are replaced by inflated round or oval blue-green bladderlike structures. Infected plants produce little seed, but the percentage 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. It is transmitted by the aster leafhopper, *Macrosteles fascifrons*. The amount of aster yellows depends on the number of leafhoppers that migrate in from overwintering areas to the south, the percentage of leafhoppers carrying the aster yellows phytoplasma and the time of arrival of the leafhoppers.

Disease Management

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

Fusarium Wilt

Cause

Fusarium species

Signs and Symptoms

Affected plants first will exhibit stunting and foliar discoloration and eventually may wilt, leading to premature death. Pods of infected plants may be reduced in size and have few to no seeds. Fusarium wilt causes discoloration of the water-conducting vascular tissues in the upper roots and, when the disease is severe, in the lower stems; if a cross-section is cut through roots or lower stem tissues of infected plants, reddish-brown discoloration of the vascular tissues will be apparent. Yellow to brown streaking also may be observed along one side of the stem of infected plants.

Survival and Spread

In Canada, Fusarium wilt can be caused by either of the fungi *Fusarium avenaceum* or *F. oxysporum*. 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 yet been observed in the U.S. Crop rotation with cereal crops may reduce inoculum levels in the field. Data collected in Canada have shown that differences in cultivar susceptibility exist.

Root Rots

Several root and crown rots have been reported in North America. Seed decay and seedling diseases occur, but they usually are of minor importance. Foot rot (basal stem rot), caused by *Fusarium* spp. and *Rhizoctonia solani*, 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, caused primarily by *Rhizoctonia solani*, is a serious disease of Polish canola *(B. rapa)* in the Peace River region of northern Alberta, but it is not important elsewhere. A crown rot caused by *Rhizoctonia* sp. was reported in Indiana. No serious seedling disease or root rot problems have been reported in Minnesota or North Dakota.

Frost Tolerance and Frost Damage

Hans Kandel,
Extension Agronomist,
and
Duane R. Berglund,
Extension Agronomist Emeritus

Frost can occur in any month; however, frost occurring in the spring and late August or early September can be critical. The temperature at which freezing injury occurs varies with the plant's stage of growth, soil 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 that lasts only a very short time may not damage canola plants, while a light frost of a 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 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, take no action for at least four to seven days.

The extent of the injury can be determined in a week or less following the frost. If you see any green 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 later-sown canola that did not undergo hardening was killed by temperatures of 25 to 26 F. 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, one 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 they will 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 to reach maturity.

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 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 seeds of lower quality because the damaged seeds will retain their green color, which will reduce the grade.

Hail Damage

Hans Kandel,
Extension Agronomist,
and
Duane R. Berglund,
Extension Agronomist Emeritus

When hail storms occur, what kind of damage and injury can you 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 *(see tables)*. 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. 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.

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 developing flowers that normally would have aborted. New branches also develop from

growth buds lower on the plant. Seed yield loss will depend on both the percentage 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, flower, and mature is limited before a killing frost. Canola seed yield loss, if injury occurs at the ripening stage, 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 shattering of pods causing economic seed loss.

Percent yield loss from canola stand reduction.

Original plants per 10 feet of row	Percent stand reduction									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Percent yield loss									
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

Percent yield loss from defoliation of canola.

Stage of Growth	Average percentage of leaf area destroyed									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Percent yield loss									
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 through branching	1	2	2	3	4	5	6	6	7	8

Source: National Crop Insurance Service.

Swathing and Harvest Management

John Nowatzki,
Extension Agricultural Machine Systems Specialist;
Hans Kandel,
Extension Agronomist;
and
Brian Jenks, Weed Scientist

Straight Combining vs. Swathing

Producers traditionally have swathed rather than straight combined canola; however, straight combining is an option for certain types of canola when specific conditions exist. Straight combining can save time and money, and result in improved seed quality. Canola Council of Canada research has shown straight combined and swathed yields were equal, with some straight combining trials showing increased seed size and oil content.

Heavier stands that are slightly lodged are better suited for straight combining than thinner stands because of the decreased likelihood of shattering from wind. Straight combining of canola has resulted in yield losses of 8 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. However, 15 to 20 percent of canola in North Dakota is straight combined successfully.

As of 2011, diquat is the only product labeled for use as a preharvest desiccant in canola. Growers can maintain excellent canola yield and quality if the diquat application is timed properly and the crop harvested in a timely manner. Diquat should be applied when 60 to 75 percent of the seeds have started to turn color. Canola seeds mature in the bottom pods first, while the last seeds to mature are in the top pods. Apply the desiccant when seed in the middle pods (or 60 to 75 percent) have started to turn color. Research has shown that when the desiccant is timed properly, crop quality parameters, including canola yield, test weight, oil content, seed loss, green count and grade, generally were similar for desiccated canola compared with swathing.

However, diquat applied too early could result in lower yield and seed quality, with a trend toward higher green content. Diquat requires a seven-day preharvest interval. Research has shown that canola harvested 14 days after application will have lower green content than canola harvested seven days after application. Fields with excessively lodged canola may be difficult to desiccate because the spray droplets may not be able to penetrate the canopy. Therefore, swathing may be the better choice for lodged canola.

Swathing

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 occurs 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 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 to 35 percent, about 30 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 to 50 percent seed color change in just three to five days or less. Once filled, 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. Swathing can begin in Argentine canola at 15 percent seed color change. Polish canola should be left until 20 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 in which 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 canola must flow smoothly through the swather without bunching. Bunching leads to uneven drying and combine plugging. Therefore, a swather for canola 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 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 as far forward as possible. Reel speed should be set to correspond with the forward speed of the swather. 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, finger reels are highly recommended 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 is almost

inevitable unless special vertical cutter bars or power blades are fitted on the swather. 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 will be difficult to pick up without shelling the canola. NDSU research has 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 (around 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, after a 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, to the late-emerged flush of young, more immature plants. Knowing the ratio of early to late-emerged canola plants allows making a better decision as to how soon to swath or to wait until the later crop catches up. If the stand is 20 to 25 percent early and 75 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 to 14 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 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 the 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 the 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) accumulations 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

Most combines work fairly well to harvest canola. Combines should be checked thoroughly before starting on canola. Cover any holes or worn spots in the table/platform or within a combine with duct tape or caulking compound. Leakage can occur easily in the stone trap or top feeder housing, or through lower inspection doors. The 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. Cracked canola is caused by impact when the cylinder speed is too fast. 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 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 a low fan speed and increase gradually until the separation of chaff and seed occurs with no canola being blown over the chaffer sieve.

Canola Drying and Storage Management

Kenneth Hellevang,
Extension Engineer

Factors affecting canola storage include seed maturity and condition, seed moisture, temperature, length of storage, molds, insects and mites, dockage, cultivar type, climate, and the storage and handling methods used.

Harvesting at the proper stage is very important in having a high-quality product. The seed needs to be yellow or brown before harvesting. If more than 2 percent of the seed is green when crushed, the canola is discounted severely at marketing. Some color change may occur during high-temperature drying, but very little color change is expected during storage.

Canola is a small, round seed that flows freely, so tight containers are required to store canola. The diameter of a canola seed ranges from 3/64 to 3/32 inch, depending on variety. Assure that aeration floors are designed for canola. Inspecting floors and unloading augers also is a good idea. The density of canola is specified at 50 pounds per bushel.

Recommended Storage Moisture

The recommended moisture content for storage at warm summer temperatures is 8 percent wet basis for canola at about 35 percent oil content. As the oil

content increases above 35 percent, the moisture content for safe storage must decrease. At 45 percent oil content, the recommended long-term storage moisture content at warm summer temperatures is about 7 percent. Storing 10 percent moisture and 45 percent oil canola at 80 F would be similar to storing wheat at 16 percent moisture content. The allowable storage time would be about 40 days.

The allowable storage time can be determined from a chart for cereal grains by subtracting 6 percent from the cereal grain moisture content. For example, the allowable storage time of 18 percent moisture content wheat at 60 F is about 50 days, so the estimated allowable storage time for 12 percent moisture content canola at 60 F is about 50 days. Canola can be stored at higher moisture contents as long as it is kept cool using aeration. The allowable storage time is approximately doubled for each 10-degree F reduction in canola temperature, so keeping the stored canola cool greatly extends its storage life.

Moisture meters are calibrated for mature seeds at a specific moisture and oil content. Anytime the seed or kernel changes, the accuracy of the moisture measurement will be affected.

When the kernel or seed is damaged, it is more prone to storage problems. A correlation has been found between low-test-weight grain and a shorter storage life. Sprouted canola should be dried to a moisture content at least a point lower than normal for storage, and the allowable storage time will be shorter.

Cooling grain with aeration is more important if kernel integrity is poor.

Storage management, including aeration, is critical. Heating during storage 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 period of a high respiration rate producing heat and moisture during the first weeks of storage. The respiration will be greater at higher moisture contents and temperatures. Aeration and frequent monitoring of the canola during this period is very important.

The spoilage time of freshly harvested rapeseed stored aerobically in tubes, without aeration, demonstrates the importance of immediate aeration to control the rapid respiration after harvest. Seed clumping, which is caused by mold mycelia, preceded the appearance of visible mold colonies.

Maximum period (days) without visible "clumping" of canola by molds.

	Temperature F				
Moisture	**80**	**70**	**60**	**50**	**40**
(percent)	—— Days without clumping ——				
17.0	4	4	6	11	20
15.6	4	6	6	11	28
13.7	4	6	11	20	46
12.3	8	6	18	25	109
10.6	11	18	42	42	238
8.9	23	48	116	279	300
6.7	69	180	300	300	300

The canola should be aerated within days after being placed in storage until all the canola has been cooled uniformly to outdoor air temperature. Then is should be 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 in cold winter climates. Temperatures should be checked frequently (every couple of days) after the initial binning. Observations may be less frequent (every two to three weeks) after the canola has been cooled.

At 70 F, mites develop from egg to adult in about 14 days; however, at a temperature of 40 F, development will take several months. Except for the immediate aeration because of the initial higher respiration of canola, storage management is similar to storing grain.

Grain bags do not prevent spoilage or insect infestation, so grain needs to be placed into the bags at a similar or lower moisture content than in storage in bins.

Airflow Resistance

The type of canola affects the aeration system design, operating static pressure, airflow and fan selected. The resistance to airflow (static pressure) of Argentine canola is about twice that of wheat, and for Tobin canola, it is about three times that of wheat. Fans must be selected to operate at the appropriate static pressure. For example, to obtain an airflow rate of 0.2 cfm/bu (cubic feet per minute per bushel) in a 36-foot-diameter bin filled 24 feet deep with

B. napus (Argentine, Westar) canola, you would need a 4.5-horsepower fan operating at 4.4 inches of static pressure. The Argentine is the most common type of canola grown. Obtaining that same airflow rate through *B. rapa* (Polish, Tobin) canola requires a 6.8-horsepower fan operating at 6.6 inches of static pressure. If a 5-horsepower low-speed centrifugal fan is placed on the 36-foot-diameter bin filled 24 feet deep with Argentine canola, an airflow rate of 0.23 cfm/bu is obtained. However, if the same fan is placed on the bin of Polish canola, an airflow rate of only 0.18 cfm/bu is obtained.

Natural Air Drying

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 *B. napus* "Argentine" canola at selected airflow rates and static pressures.

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

Equilibrium Moisture Content

Based on average North Dakota 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 with an airflow rate of 0.75 cfm/bu, it is about 35 days.

Equilibrium moisture content of canola at certain air conditions.

	Temperature (F)						
Relative Humidity	**20**	**30**	**40**	**50**	**60**	**70**	**80**
(percent)							
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

High-temperature Drying

High-temperature dryers work for drying canola, but check the screen size on column dryers because most are equipped with a standard-size perforation of 3/32 inch through which canola seed may pass or lodge. Check with the dryer manufacturer before making any changes to be sure fan operation will not be affected adversely.

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 that is used for seed should be dried at temperatures less than 110 F. If the moisture content is above 17 percent, drying the kernels in two passes is advantageous. Too much moisture extracted at one pass can lead to shriveling and cracking of the seed, as well as limit the drying performance.

Overdrying causes cracking of the seed coats. Damaged seeds undergo a marked rise in the level of free fatty acids, causing a reduction in oil quality. 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.

Fire risk when drying canola may be reduced by cleaning the seed to remove light or fine material before drying, removing accumulations of debris from the walls and other areas of the dryer, using wind deflectors to prevent drawing airborne material through the burner, and avoiding overdrying the seed. Frequently check the dryer and periodically clean it to reduce the fire hazard.

Handling Canola

Operate augers at full capacity and moderate speeds to avoid excessive damage to the seed. Drag conveyors have been used successfully, but experience with canola suggests that the spacing between paddles should be reduced to maintain satisfactory capacity. Pneumatic conveyors can handle canola adequately but may have difficulty in feeding and discharging the seed. Kernel damage usually is not a problem for most equipment unless the moisture content is below 7 percent.

USDA market grades and grade requirements of canola.

Grading factors maximum percent limits of:	— U.S. Grades — 1	2	3
	——— Percent ———		
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[1]			
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[2]	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.

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

[2] **Inconspicuous admixture.** Any seed that 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.

Contributors to Canola Production Field Guide

Authors

- Duane Berglund
  Agronomist Emeritus, NDSU Extension Service
- Pat Beauzay
  NDSU Entomologist
- Dave Franzen
  Soil Science Specialist, NDSU Extension Service
- Kenneth Hellevang
  Agricultural Engineer, NDSU Extension Service
- Brian Jenks
  Weed Scientist, North Central Research Extension Center, NDSU
- Hans Kandel
  Agronomist, NDSU Extension Service
- Janet Knodel
  Entomologist, NDSU Extension Service
- Samuel Markell
  Plant Pathologist, NDSU Extension Service
- Luis del Rio Mendoza
  NDSU Plant Pathologist

- John Nowatzki
  Agricultural Machine Systems Specialist,
  NDSU Extension Service
- Michael Wunsch
  Plant Pathologist, NDSU Extension Service
- Richard Zollinger
  Weed Specialist, NDSU Extension Service

Others

- R. Ashley, G. Endres, E. Eriksmoen,
  M. Halvorson, B. Hanson, B. Johnson, L. Olson,
  J. Pederson, N. Riveland and B. Schatz.
  NDSU Research Extension Center and Extension
  agronomists
- Phillip Glogoza
  Regional Extension Educator,
  University of Minnesota
- Bill Wilcke
  Extension Engineer, University of Minnesota

Resource Contact Information

NDSU Extension and NDSU Research Extension Centers

Name	Function and Email	Telephone 701 Area Code
Ashley, Roger	Area Extension Agronomist – Dickinson *roger.ashley@ndsu.edu*	483-2348
Beauzay, Patrick	Entomologist/Research Specialist *patrick.beauzay@ndsu.edu*	231-7064
Endres, Greg	Area Extension Agronomist – Carrington *gregory.endres@ndsu.edu*	652-2951
Eriksmoen, Eric	Agronomist – Hettinger *eric.eriksmoen@ndsu.edu*	567-4325
Franzen, David	Extension Soils Specialist *david.franzen@ndsu.edu*	231-8884
Halvorson, Mark	Agronomist – Minot *mark.halvorson@ndsu.edu*	857-7677
Hanson, Bryan	Agronomist – Langdon *bryan.k.hanson@ndsu.edu*	256-2582
Hellevang, Ken	Extension Ag. Engineer *kenneth.hellevang@ndsu.edu*	231-7243
Jenks, Brian	Weeds Agronomist – Minot *brian.jenks@ndsu.edu*	857-7677

Johnson, Burton	Agronomist – NDSU *burton.johnson@ndsu.edu*	231-8895
Kandel, Hans	Extension Agronomist *hans.kandel@ndsu.edu*	231-8135
Knodel, Janet	Extension Entomologist *janet.knodel@ndsu.edu*	231-7581
Markell, Samuel	Extension Pathologist *samuel.markell@ndsu.edu*	231-7056
Olson, Lionel	Extension Agent – Grand Forks County *lionel.olson@ndsu.edu*	780-8229
Pederson, Jeremy	Area Extension Agronomist – Minot *jeremy.pederson@ndsu.edu*	857-7679
_____	Agronomist – Williston	774-4315
Schatz, Blaine	Agronomist/Director – Carrington *blaine.schatz@ndsu.edu*	652-2951
Waldstein, Daniel	Area Crop Protection Specialist *daniel.waldstein@ndsu.edu*	857-7682
Wunsch, Michael	Extension Pathologist *michael.wunsch@ndsu.edu*	652-2951
Zollinger, Richard	Extension Weeds Specialist *r.zolling@ndsu.edu*	231-8157

Useful Websites

North Dakota State University

Variety Trial Results – Canola
www.ag.ndsu.edu/varietytrials/canola

"Canola Production," Pub. A-686
www.ag.ndsu.edu/pubs/plantsci/crops/a686w.htm

Oilseeds and Row Crops
www.ag.ndsu.edu/broadleaf/canola

North Dakota State University Extension
www.ag.ndsu.edu/waterquality/procrop/canola

Sclerotinia Risk in Canola Forecast Program
www.ag.ndsu.edu/sclerotinia/

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

Minnesota Agricultural Experiment Station

Variety Trial Results Canola
www.maes.umn.edu/vartrials/canola/index.asp

Canola Organizations

Northern Canola Growers Association
2718 Gateway Ave, #301, Bismarck, ND 58503
Phone: (701) 223-4124
Toll free: (877) 585-1671 Fax: (701) 223-4130
Email: info@northerncanola.com
Web: *www.northerncanola.com*

Minnesota Canola Council
4630 Churchill St., Suite #1
St. Paul, MN 55126
Phone: (651) 638-9883
Email: mncanola@comcast.net

U.S. Canola Association
600 Pennsylvania Ave. S.E., Suite 320
Washington, DC 20003
Tele: (202) 969-8113
Email: info@uscanola.com
Web: *www.uscanola.com*

Canola Council of Canada
400 - 167 Lombard Ave., Winnipeg, MB R3B 0T6
Phone: (204) 982-2109
Web: *www.canolacouncil.org/*

Other Resources

Saskatchewan Department of Agriculture and Food
Web: *www.agriculture.gov.sk.ca/canola*

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

Canola Growers Manual, Canola Council of Canada
Web: *www.canolacouncil.org/canola_growers_manual.aspx*

Resource Publications

NDSU Extension Publication	A-686	Canola Production
NDSU Extension Publication	A-1124	Canola Variety Trials
NDSU Extension Publication	SF-1122	Fertilizing Mustard and Canola
NDSU Extension Publication	W-253	North Dakota Weed Control Guide
NDSU Extension Publication	PP-1367	Blackleg of Canola
NDSU Extension Publication	PP-1410	Sclerotinia of Canola
NDSU Extension Publication	A-1171	Swathing and Harvesting of Canola
NDSU Extension Publication	E-1143	North Dakota Field Crop Insect Management Guide
NDSU Extension Publication	PP-622	North Dakota Field Crop Fungicide Guide
NDSU Extension Report	E-1234	Biology and Integrated Pest Management of the Crucifer Flea Beetle in Canola
NDSU Extension Report	E-1346	Bertha Armyworm in Canola: Biology and Integrated Pest Management
NDSU Extension Report	E-1347	Diamondback Moth in Canola: Biology and Integrated Pest Management

109

CANOLA – AGRONOMY

Early season sulfur deficiency.
(NDSU Extension)

Later-season sulfur deficiency.
(NDSU Extension)

Various pod maturity.
NDSU Extension)

Seed maturity.
(NDSU Extension)

Swather with cutter bar.
(NDSU Extension)

Canola in the swath.
(H. Kandel, NDSU)

110

CANOLA – WEEDS

Barnyard grass.
(NDSU Extension)

Biennial wormwood, seedling.
(NDSU Extension)

Biennial wormwood, adult.
(NDSU Extension)

Black nightshade.
(NDSU Extension)

Canada thistle.
(NDSU Extension)

Cocklebur.
(NDSU Extension)

111

CANOLA – WEEDS

Common mallow.
(NDSU Extension)

Common ragweed.
(NDSU Extension)

Field bindweed.
(NDSU Extension)

False chamomile, adult.
(NDSU Extension)

False chamomile, flowers.
(NDSU Extension)

Field pennycress.
(NDSU Extension)

112

CANOLA – WEEDS

Flixweed.
(NDSU Extension)

Green foxtail.
(NDSU Extension)

Horseweed, immature.
(NDSU Extension)

Horseweed.
(NDSU Extension)

Kochia.
(NDSU Extension)

Lambsquarters.
(NDSU Extension)

CANOLA – WEEDS

Marshelder.
(NDSU Extension)

Pennsylvania smartweed.
(NDSU Extension)

Perennial sowthistle.
(NDSU Extension)

Pigweed.
(NDSU Extension)

Russian thistle.
(NDSU Extension)

Shepherdspurse, rosette.
(NDSU Extension)

CANOLA – WEEDS

Wild buckwheat.
(NDSU Extension)

Wild mustard.
(NDSU Extension)

Wild oat.
(NDSU Extension)

Wild sunflower.
(NDSU Extension)

Yellow foxtail.
(NDSU Extension)

CANOLA – INSECTS

Adult crucifer flea beetle, *Phyllotreta cruciferae* (Goeze).
(G. Fauske, NDSU)

Adult striped flea beetle, *Phyllotreta striolata* (Fabricius).
(G. Fauske, NDSU)

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

Adult diamondback moth, *Plutella xylostella* (Linnaeus).
(G. Fauske, NDSU)

Damaged canola seedling caused by flea beetle feeding injury (top) and undamaged seedling (bottom).
(J. Knodel, NDSU)

Damage from diamondback moth larvae (aborted flowers).
(J. Knodel, NDSU)

CANOLA – INSECTS

Adult bertha armyworm, *Mamestra configurata* (Walker).
(G. Fauske, NDSU)

Black and green phase of larvae of bertha armyworm.
(J. Knodel, NDSU)

Damage caused to pods from feeding by larvae of bertha armyworm.
(J. Knodel, NDSU)

Adult tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois).
(Courtesy S. Bauer, Agricultural Research Service, U.S. Department of Agriculture)

Nymph of tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois).
(Courtesy S. Bauer, Agricultural Research Service, U.S. Department of Agriculture)

Adult red-backed cutworm, *Euxoa ochrogaster* (Guenee) typical form.
(G. Fauske, NDSU)

117

CANOLA – INSECTS

Adult red-backed cutworm, *Euxoa ochrogaster* (Guenee), dark form.
(G. Fauske, NDSU)

Adult red-backed cut-worm, *Euxoa ochrogaster* (Guenee), pale form.
(G. Fauske, NDSU)

Larvae of red-backed cutworm.
(J. Knodel, NDSU)

Adult two-striped grasshopper, *Melanoplus bitvittatus* (Say).
(J. Knodel, NDSU)

Adult Nuttall blister beetle, *Lytta nuttalli* (Say).
(J. Knodel, NDSU)

Cluster of turnip aphids, *Lipaphis erysimi* (Kaltenbach) on canola terminal.
(J. Knodel, NDSU)

118

CANOLA – DISEASE

Alternaria black spot.
(H. Kandel, NDSU)

Aster yellows (close-up).
(NDSU Extension)

Blackleg stem lesion.
(S. Markell, NDSU)

Blackleg.
(S. Markell, NDSU)

Blackleg foliar lesion.
(S. Markell, NDSU)

Blackleg foliar lesion.
(S. Markell, NDSU)

CANOLA – DISEASE

Clubroot.
(NDSU Extension)

Fusarium wilt.
(Courtesy D. Kaminski, Manitoba Agriculture)

Rhizoctonia root rot.
(NDSU Extension)

Sclerotinia stem rot.
(L. del Rio, NDSU)

Sclerotinia sclerotiorum apothecia.
(S. Markell, NDSU)

White rust (staghead).
(NDSU Extension)

NOTES

The NDSU Extension Service
does not endorse commercial products
or companies even though
reference may be made to trade names,
trademarks or service names.

For more information on this and other topics, see: www.ag.ndsu.edu

County Commissions, NDSU and U.S. Department of Agriculture Cooperating.
This publication will be made available in alternative formats for
people with disabilities upon request, (701) 231-7881.

4M-6-11