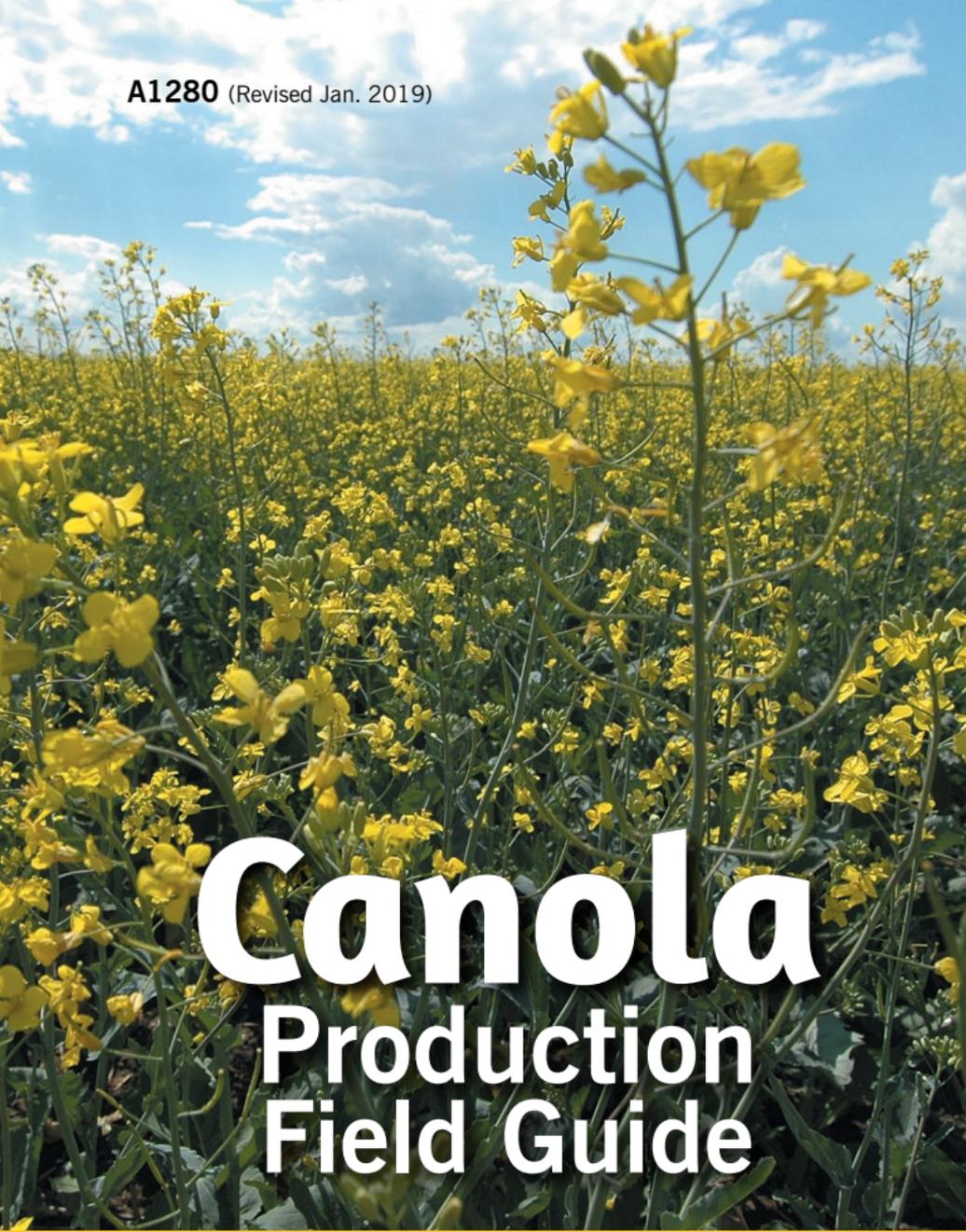


A1280 (Revised Jan. 2019)



Canola

Production Field Guide

NDSU

EXTENSION

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

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Introduction

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Canola is a popular oilseed cash crop in North Dakota. North Dakota leads the U.S. in canola production (in pounds), with approximately 82 percent of the domestic production in 2017. Approximately 1.56 million acres were harvested in North Dakota in 2017. Statewide yields have averaged from 1,380 to 1,840 pounds per acre during the period 2008-2017 (Figure 1).

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

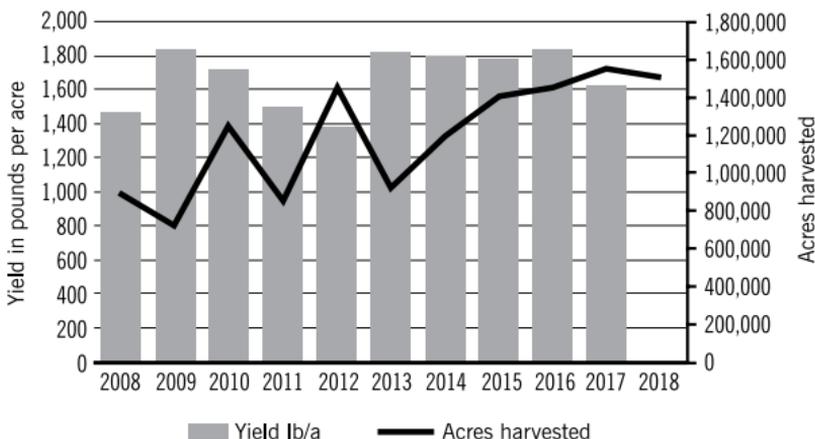


Figure 1. Canola yield in pounds per acre and harvested acres from 2008 to 2018.

Canola hybrids must have an erucic acid content of less than 2 percent and less than 30 micromoles of glucosinolates per gram of seed. These qualities makes canola 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 hybrids. High-erucic acid oil rapeseed is used for industrial lubricants. This type of rapeseed is mostly grown in Europe, although some production occurs in the U.S. and Canada.

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 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 Hybrids 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 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 hybrid 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. Winter canola planted in the fall does not reliably survive the harsh winter conditions of 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. *Brassica rapa* (Polish canola) hybrids are more adapted to shorter growing seasons and where soil moisture may be limited. 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 hybrids 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. *Brassica juncea* subsp. *juncea* canola was developed fairly recently in Canada and is approved to grow in the U.S. This species is more suitable to hot and dry conditions. *Brassica juncea* pods do not shatter as easily as other canola types.

Herbicide-tolerant canola (HTC) hybrids with resistance to a specific herbicide have been developed. Available HTC traits are: Roundup Ready (active ingredient glyphosate), Liberty Link (active ingredient glufosinate), SU-tolerant (active ingredient sulfonyleurea), Clearfield (active ingredient imidazolinone or Imi) and triazine-tolerant. Roundup Ready and Liberty Link traits were developed through genetic modification. SU tolerance was achieved via gene editing technology. Clearfield and triazine-tolerant hybrids were developed from traditional breeding techniques.

Additionally, plant breeders have developed hybrids for specialty markets, which are seeking canola oils with specific industry needs and require modification to canola's standard fatty acid profile. This demand includes high-erucic acid rapeseed (HEAR) that is used in plastics,

lubricants, lacquers and detergents. Special-use hybrids should be grown only on a contract basis and must remain identity preserved and segregated.

Hybrid Selection

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

- **Yield** – Select hybrids with consistently high yields.
- **Maturity** – *B. napus* canola hybrids 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 hybrids with resistance to blackleg. Hybrids with superior lodging resistance reduce the incidence of sclerotinia.
- **Seedling vigor** – Hybrids with good seedling vigor will be more competitive with weeds and more likely to push through a shallow crust.

Hybrid trial results are available from NDSU. See NDSU Extension publication A1124 (www.ag.ndsu.edu/variety_trials/canola) for the most recent hybrid yield results.

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 hybrid.

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 energy. 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. The vast majority of photosynthesis occurs in the leaves, 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 for 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 dry conditions can reduce yield potential severely during this stage.

Ripening

Ripening begins when the petals on the last flower on the main stem drop. By the time flowering is finished, most of the leaves have yellowed and fallen off. 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 brown. If using a contact herbicide for desiccation, the recommended application timing is when 60 to 75 percent of the seed has turned brown, which is past the stage when swathing typically would be recommended.

Spring *B. napus* usually matures 85 to 110 days after planting, depending on hybrid and environmental conditions.

Growth-stage Key

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

Stage Description of Main Raceme

0 Pre-emergence

1 Seedling

2 Rosette

2.1 First true leaf expanded

2.2 Second true leaf expanded

2.3 Continue for each additional leaf

3 Bud

3.1 Flower cluster visible at center of rosette

3.2 Flower cluster raised above level of rosette - "bolting"

3.3 Lower buds yellowing

4 Flower

4.1 First flower open

4.2 Many flowers open, lower pods elongating

4.3 Lower pods starting to fill

4.4 Flowering complete, seed enlarging in lower pods

5 Ripening

5.1 Seeds in lower pods full size, translucent

5.2 Seeds in lower pods green

5.3 Seeds in lower pods green-brown or green-yellow, mottled

5.4 Seeds in lower pods yellow or brown

5.5 Seeds in all pods brown, plant dead

Rotations

Canola does well following cereal grains, most legumes or fallow in rotation. Research at various Research Extension Centers indicated that no yield difference occurs if canola is seeded after wheat or soybean. A preferred crop rotation would have at least two cropping years between canola plantings. However, if seeding canola after one year out, we recommend growing a hybrid that is resistant to black-leg.

Canola is susceptible to sclerotinia stem rot. White mold (sclerotinia) infection risk increases if canola is planted in tight rotation with other highly susceptible crops, such as sunflowers or dry edible beans. If planting canola within three years of susceptible crops, a fungicide application may be needed.

Less susceptible crops that could be planted successfully in a close rotation with canola are soybeans, flax, semileafless field peas or lentils. In years when ideal environmental conditions favor air-borne spore movement, all canola plantings without fungicide applied, regardless of rotation intervals, may have economic losses due to sclerotinia.

Canola is certain to shatter seeds, and volunteer plants are likely the next season. Cereals should follow canola to allow the use of certain broadleaf phenoxy herbicides for volunteer canola control.

Corn should not follow canola in a rotation because canola does not support arbuscular mycorrhizal fungi, which aid in corn phosphorous uptake. Also, avoid the production of canola and tame mustard on the same farm. A mixture of the two crops reduces the market value of both. In addition, conventional canola should not be planted on fields with heavy infestations of wild mustard. Roundup Ready,

Liberty Link, Clearfield or SU canola can be planted to manage wild mustard in canola fields.

Herbicide carryover from previous crops can injure new canola seedlings. These include sulfonyleurea (except the SU canola), imidazolinone (except Imi canola), triazine and PPO classes of herbicides. Always refer to the herbicide label information pertaining to crop rotation restrictions following their use.

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 getting proper soil-to-seed contact in cloddy soil 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 seeded on salt-affected soils because it is not salt-tolerant.

Canola can be grown in no-till or conventional tillage systems. Avoid excessive tillage in the spring to prevent the seedbed from drying out because seed must be placed in moist soil, which is critical for rapid emergence.

Canola also is very susceptible to soil crusting; however, the seedbed must be firm for seeding. We do not recommend seeding canola into dry or excessively wet soils. If crusting occurs, do not try to remedy the issue with light tillage because this will damage seedlings.

Planting Guidelines

Canola can be planted with a variety of seeding equipment, but canola usually is planted with a drill. However, having good depth control is important. The optimum seeding depth for canola is $\frac{1}{2}$ to 1 inch, and should not exceed an inch with small-seeded hybrids. Large-seeded hybrids may be seeded deeper than 1 inch; however, planting depth should not exceed $1\frac{1}{2}$ inches. Seed canola where a uniform depth can be achieved.

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 with a harrow is essential. During a very wet spring, using an airplane to broadcast the seed is possible as long as the producer is aware of the risk of uneven emergence.

In no-till, we recommend an even distribution of surface residue to help 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 cereal grains. To maximize yield, canola should be planted in April to early May. NDSU researchers have evaluated the effect of planting date on canola yield at different locations. Data collected for Minot from 1998, 2010 and 2011 studies, and for Langdon from 1989-1994, 1992-1995 averages, and 2010 and 2011 were used to construct response curves for the different locations (Figures 2 and 3). Yields were expressed as the percent of the highest yield obtained from each separate experiment.

The graphs indicate that canola yield potential decreased as planting was delayed. At the most northern location, Langdon, the yields stayed relatively stable from the earliest plant date though the third week of May. At Minot, yields tended to decrease more rapidly after the optimum seeding date (first part of May).

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 *Brassica napus* (Argentine) hybrids and 3 to 6 pounds for *Brassica rapa* (Polish) hybrids. A common rule of thumb for seeding canola is 5 pounds per acre or 10 acres per 50-pound bag.

In high-yielding canola production areas, farmers have been using lower rates due to high seed costs and canola's ability to compensate for yield with lower stands. Canola

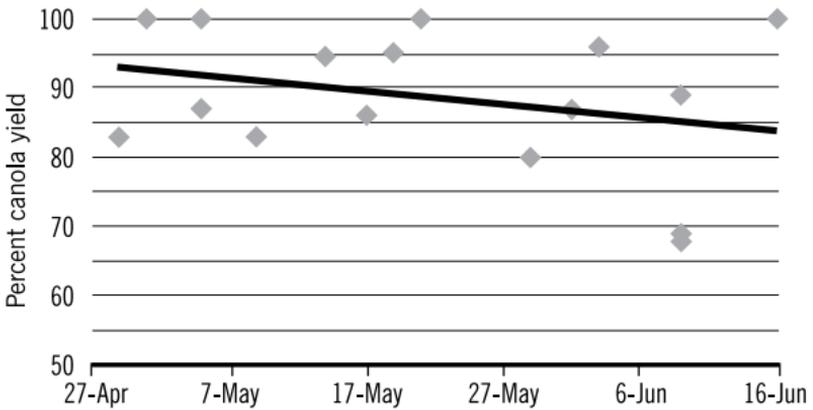


Figure 2. Percent of canola yield by planting date at Langdon REC, averaged for 1989-94, 1992-95, 2010 and 2011.

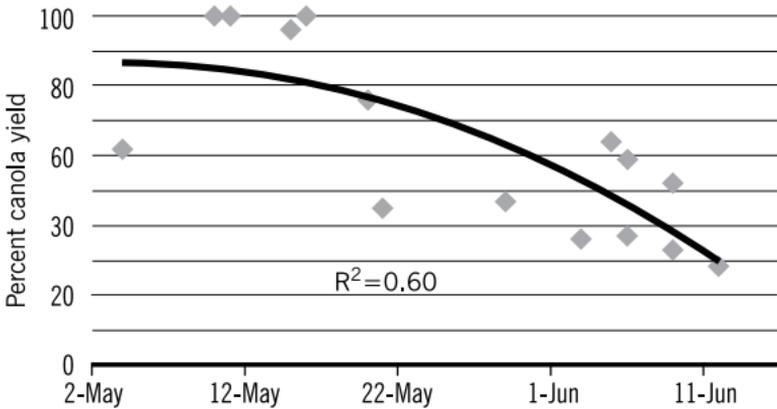


Figure 3. Percent of canola yield by planting date at North Central REC, Minot, averaged for 1998, 2010 and 2011.

hybrids have different seed sizes, resulting in differences in seeds per pound. Farmers should use actual plants per square foot to calculate optimal planting rates 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.

As a general rule for the Argentine canola, hybrids will contain 75,000 to 100,000 seeds per pound, whereas open-pollinated hybrids will contain a range of 135,000 to 160,000 seeds per pound. Seed counts for Polish hybrids 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 hybrids, stands can be as low as two plants per square foot, providing weeds are controlled and plants are uniformly spaced with no large gaps.

Dormant seeding

Dormant seeding of spring canola is 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 areas with variable winter temperatures and snow fall.

Frost Tolerance and Frost Damage

Frost can occur in any month in North Dakota; however, frost occurring in the spring or late summer is of most concern to canola growers. 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 recover from a light spring frost that does not damage the growing point of the plant. If a heavy frost blackens the leaves, take no action for at least four to seven days to observe the extent of the injury. If you see any green at the growing point in the center of the frozen 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 percent of plants killed, the percent recovered and time of the year. The surviving plants also should be somewhat evenly distributed in a field when allowing the stand to remain. 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.

Short-duration frost at flowering will delay maturity but results in only minor yield reductions. 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 damage.

Frost after flowering, however, can result in significant yield reductions and grade loss. 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 early and uniformly 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

When hail storms occur, what kind of damage and injury can you expect? A general rule is that the earlier in canola 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 Table Percent yield loss). 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 was 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.

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
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.

	Average percentage of leaf area destroyed									
	10	20	30	40	50	60	70	80	90	100
Stage of Growth	10	20	30	40	50	60	70	80	90	100
Vegetative Through Start of Flowering	2	4	6	10	12	15	18	20	22	25
5 Days After Flowering	2	3	5	6	8	10	11	13	14	16
10 Days After Flowering Up Through Branching	1	2	2	3	4	5	6	6	7	8

Source: National Crop Insurance Service.

Seed yield loss will depend on 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.

Soil Fertility Requirements

Dave Franzen, Extension Soil Science Specialist

Mineral nutrient requirements for canola

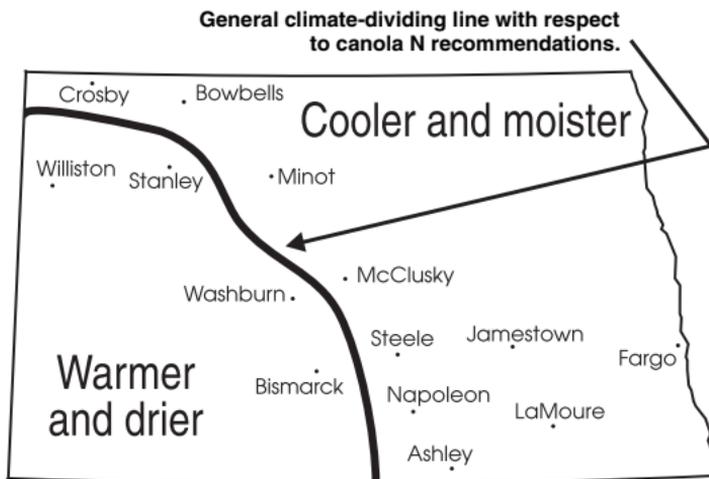
Nitrogen (N), phosphorus (P) and potassium (K) requirements of canola and mustard are similar to those of small grains. Sulfur (S) requirements for canola are higher than most crops.

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 should be tested on each depth. The S soil test is non-diagnostic, so it should not be used to make a decision. The savvy grower will choose to not include S in the soil analysis suite.

Nitrogen

All nutrient recommendations, including N, are not dependent on yield. A similar N rate is appropriate for greatest profit/yield in a poor as well as a good production season. 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 seeding.

Canola is very sensitive to fertilizer salts. No more than 5 pounds per acre (lb/a) of N is recommended with the seed in 12-inch row spacing for medium-textured soils, but the rate can be increased proportionally with narrow row spacing or increase in seed spread (see table labeled **Maximum rates of seed-placed N + K₂O for canola**).



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.

Phosphorus and Potassium

P and K recommendations are shown in table labeled **N, P and K recommendations**. Canola is a good scavenger of P, and a row-starter fertilizer rate of 20 to 30 pounds of P_2O_5 per acre is sufficient for most soil test levels. On light soils where no N is recommended, 11-52-0 (MAP) would be a better seed-placed choice of phosphate because its N component is not as likely to injure seed as 18-46-0 (DAP).

Potassium, 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 labeled Maximum rates of seed-placed K_2O for canola). 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 and mustard.

Soil N + Supplemental N lb/a	Olsen-P, ppm						Soil Test K, ppm					
	VL	L	M	H	H	H	VL	L	M	M	H	VH
	0-3	4-7	8-11	12-15	16+	16+	0-40	41-80	81-120	121-150	150+	
2 feet depth	lb P₂O₅ /acre											
120*	60	44	28	12	0	0	90	60	40	20	0	
150**	60	44	28	12	0	0	90	60	40	20	0	

* Indicates cap for warmer and drier areas in the state.

** Indicates cap for cooler, moister areas in the state.

Maximum rates of seed-placed N + K₂O for canola.

Soil Texture	Disc or Knife (1-inch spread) Row Spacing			Spoon or Hoe (2-inch spread) Row Spacing			Sweep (4- to 5-inch spread) Row Spacing		
	6 in.	9 in.	12 in.	6 in.	9 in.	12 in.	6 in.	9 in.	12 in.
Light	5	0	0	lbs N + K ₂ O /a150+			30	20	15
Medium	10	5	5	20	20	15	35	25	20
Heavy	15	10	5	35	25	20	45	30	25

Sulfur

Canola has a special requirement for sulfur. The yield 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**).

The S soil test is not diagnostic for canola or any other crop. Recommended sulfur application rates are 20 to 30 pounds of S per acre.

Canola takes up sulfate-S. The form of sulfur fertilizer may be ammonium sulfate (21-0-0-24S) or other sulfate fertilizers, such as ammonium thiosulfate or potassium thiosulfate. Elemental sulfur forms have not performed well in regional trials and are not recommended because these S sources have little value in the year of application.

Application of elemental S the previous year or previous fall has not proven to be of practical value due to low oxidation rates of S and high probability of sulfate leaching. Sulfur fertilizers are best applied in the spring and should not be applied in the fall.

Micronutrients

Canola yield has not been higher with the application of 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, Rock Lake, N.D.

Rate lb S/acre	Source	Tillage	Soil Types		
			Buse	Barnes	Svea
----- 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 percent 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

Clair Keene, Agronomist, and Brian Jenks, Weed Scientist

Weed Control in Canola

A uniform stand of a competitive canola hybrid is the best weed control tool. Canola is not very competitive during early growth but becomes more competitive as it approaches the late-rosette and bolting stages. Competitive canola hybrids 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 density. 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 foot²) 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 rate, weeds controlled, when to apply, etc. This information does not supersede the herbicide label. Always read and follow label instructions.

The herbicides listed were registered for use as of the 2018 growing season. Illegal herbicide use may result in condemnation of the crop and possible fines.

Sonalan (ethalfluralin)

Rate: 5.5 to 9.5 lb 10 G; 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. Liquid formulation should not be used in no-till because it will be tied up in the residue.

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)

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. Liquid formulation should not be used in no-till because it will be tied up in the residue.

Broadcast application rates:

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

Stinger (generic clopyralid)

Rate: 4 to 8 oz SL (1.5 to 3 oz ae [acid equivalent])

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.

Liberty 280 (glufosinate) – Liberty Link canola only

Rate: 22 to 29 fl oz SL (0.4 to 0.53 lb ai)

Weeds: Controls most annual broadleaf weeds and small annual grasses

Apply: Cotyledon up to early bolting

Remarks: Apply postemergence to Liberty Link canola varieties only. Use minimum 15 gallons per acre (gpa) spray volume. Apply with AMS (ammonium sulfate) fertilizer at 1.5-3 lb/a. Liberty is a nonresidual, contact herbicide. Must apply to small grasses because Liberty only suppresses large grasses. May tank-mix with Assure II, Poast or Select to control grasses. Liberty will not control perennial weeds. See label for optimum application timing to control broadleaves and grasses based on weed size.

Beyond (imazamox) – Clearfield canola only

Rate: 4 fl oz SL (0.5 oz ae)

Weeds: Controls many annual broadleaf and grass weeds

Apply: Prior to bloom

Remarks: Apply postemergence on Clearfield hybrids 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. Allow a 60-day preharvest interval (PHI).

Glyphosate - Roundup Ready canola only

- Rate: 0.375 to 0.56 lb ae
Maximum in-crop use = 0.75 lb ae
- Weeds: Most broadleaf and grass weeds
- Apply: Emergence to bolting
- Remarks: Apply postemergence on Roundup Ready hybrids only. Apply with AMS fertilizer. Controls most annual and perennial weeds. Will not control glyphosate-resistant horseweed or kochia. 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 later but no later than the six-leaf stage. Do not apply after six-leaf stage or bolting begins because injury may occur. Allow an eight-week PHI.

Draft - (thifensulfuron + tribenuron) SU canola only

- Rate: 0.3 oz DF'
- Weeds: Small annual broadleaf weeds. Will not control ALS-resistant weeds.
- Apply: For use on Cibus SU trait canola hybrids only. Add NIS at 0.25 to 0.5 percent volume to volume (v/v). Refer to label for weeds controlled, tank-mixtures and application information.
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Assure II (quizalofop)

Rate: 7 to 12 fl oz EC (0.77 to 1.32 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. 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
Downy brome	2-6 inches	10-12 fl oz
Quackgrass	6-10 inches	10-12 fl oz

Poast (sethoxydim)

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 green foxtail 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 pt
Yellow foxtail	8 inches	1 pt
Wild oat	4 inches	1 pt
Volunteer cereals	4 inches	1.5 pt

Select 2EC (generic clethodim)/

Select Max (clethodim plus adjuvants)

Rate: 4 to 8 fl oz / 9 to 16 fl oz (1 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	1-4 inches	4/6 fl oz
Green foxtail	1-4 inches	4/9 fl oz
Yellow foxtail	1-4 inches	4/9 fl oz
Wild oat	1-4 inches	5/9 fl oz
Volunteer cereals	1-4 inches	5/9 fl oz

Preharvest herbicides for canola.

Reglone + NIS (diquat) ¹	1.5 to 2 pt 2SL + 1 qt/100 gal water (0.37 to 0.5 lb)	Desiccant	Allow seven- day PHI. Harvest no later than 10 days after application	Add NIS at 0.25 percent v/v. Nonresidual, contact herbicide requiring thorough coverage. Apply at 15 gpa spray volume. Most active in hot and sunny conditions. Maximum of one application per season. Apply when more than 60 percent of canola seed has turned from green to brown.
Glyphosate	Up to 1.125 ae	Desiccant and controls perennial broadleaf and grass weeds	Apply to mature crop with seed < 30 percent moisture. Allow seven-day PHI	Do not apply to canola grown for seed because reduced germination may occur. NDSU research has shown that 10-14 days may be required for desiccation with glyphosate alone or tank mixed with Sharpen.

Sharpen + MSO	1 to 2 fl oz SC + 1 to 1.5 pt/a	Desiccant	Allow three-day PHI	Apply Sharpen with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal and with glyphosate for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not graze or feed treated plants. Do not apply Sharpen to canola grown for seed because reduced germination may occur.
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¹Generic 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 following tables. 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

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

Herbicide	Time Interval
Assure II	1 hour
Beyond	1 hour
Glyphosate	6-12 hours
Liberty	4 hours
Poast	1 hour
Select/SelectMax	1 hour
Stinger	6-8 hours

Mode of Action	Barnyardgrass	Brome, Downy	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild Oat	Buckwheat, Wild	Cocklebur, Common	Horseweed (Marestail)	Kochia	Lambsquarters
Sonalan (PPI)	E	F-G	E ²	E	N	P	P	P	P	N	P-F	F-G
Treflan ¹ (PPI)	E	F-G	E ²	E	N	N	P-F	P	N	N	P	F-G
Stinger	N	N	N	N	N	N	N	F-G	E	G-E	N	P
Assure II/Targa	E	P-E	E	F-G	E	E	G-E ²	N	N	N	N	N
Poast	E	P-G	E	E	F	G-E	G-E ²	N	N	N	N	N
Select ¹	E	P-E	E	E	G	E	E	N	N	N	N	N
Select Max	E	P-E	E	E	G-E	E	E	N	N	N	N	N
Herbicide-resistant Canola												
Beyond	E	G-E	E	G-E	F	G-E	E ²	P	G-E	P ²	E ²	F
Liberty 280	E	-	E	G	P	F-G	G-E	E	E	F-G	G-E	F-G
Roundup ¹ /Glyphosate ³	E	G-E	E	E	E	E	E	P-G	E	G-E ²	F-E ²	P-E ²
Draft	N	N	N	N	N	N	M	G-E	N-F	N	E	G-E

PPI = Preplant incorporated.

¹Or generic equivalent.

²Herbicides will not control resistant biotypes or provide minimal control in tank-mix/premixes with alternative modes of action.

³Weed control from Glyphosate 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 ¹ (<0.68 oz DF/a)	18	Milestone	24b
Ally ¹	34cd	Nortron	12
Ally Extra ¹	22/34e	Olympus	10
Amber	B	Osprey	10
Atrazine ¹ (0.38 lb ai)	NCS	Permit/Sandea	15
Atrazine ¹ (0.38-0.5 lb ai)	2CS	Plateau	48b
Atrazine ¹ (0.5-1 lb ai)	2CS	PowerFlex	9
Authority Assist	40b	PrePare	9
Authority First/Sonic	24	Prequel	18
Authority MTZ	24	Prowl EC/H2O	NCS
Balance Flexx	18j	Pursuit	40b
Banvel ¹ (<1.5 pt)	NCS	Raptor/Beyond	18
Beyond	18	Raze	9
Boundary	12	Reflex	18
Callisto	10	Require Q	18
Callisto Xtra	NCS	Resolve Q	18
Curtail ¹ /M ¹	5	Rimfire Max	10
Everest 2.0	9	Sencor ¹	12u
Extreme	40b	Sharpen (1 fl oz)	4v
Far-Go	NCS	Sharpen (2 fl oz)	5v
Fierce	18	Sharpen (3 fl oz)	6v
FirstRate	18	Sonalan	0
Flexstar/GT	18	Spartan	24
Glean ¹	B	Spartan Advance	24
Goldsky	9	Spartan Charge	24
Halex GT	12	Starane Flex	9
Harness ¹	NCS	Status	4h
Huskie	9	Stinger ¹	0
Liberty 280	0	SureStart/TripleFlex	26b
Impact	9	Surpass ¹	NCS
Laudis	10	Tordon (1.5 oz)	2CS
Lumax (<3 pt/a)	18	Treflan ¹	0
Matrix ¹	18	Valor/Chateau	4-12
Maverick	B	WideMatch ¹	4
		Wolverine Advanced	9

continued

¹Or generic equivalent.

NCS = Next cropping season after herbicide application.

2CS = Second cropping season after herbicide application.

B or 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 flowable (DF)/a.

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* 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.

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.

Clearfield (imidazolinone resistant) canola hybrids may be planted the season after application. Conventional canola hybrids 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.

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 volunteer density. Take steps during harvest to minimize canola seed loss.

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 bury canola seeds several inches deep, 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, and control volunteers with shallow tillage or an herbicide application, then 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 a 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 poor control of bolting canola. Canola volunteers are best controlled 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

Volunteer canola control in corn.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola
	product/a		Control rating			
Accent	0.5 oz	--	E	E	--	--
Atrazine	0.75 pt	G	G	P	--	--
Balance Flexx	3 fl oz	E	--	--	--	--
Callisto	3 fl oz	E	E	G-E	--	--
Laudis	3 fl oz	--	E	G-E	--	--
Starane	0.5 pt	--	VP	VP	--	--
Status	4 oz	--	G	F	--	--
Steadfast	0.75 oz	--	E	E	--	--
2,4-D amine	0.5 pt	--	G	P	--	--

Note: Liberty Link canola will not be controlled by Liberty in Liberty Link corn or soybean. Liberty will control Roundup Ready canola in Liberty Link corn or soybean.

Volunteer canola control in sunflower.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola
	product/a		Control rating			
Assert	0.8 pt	--	E	G	--	--
Spartan	4 fl oz	P-F	--	--	--	--

Volunteer canola control in soybean.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola
	product/a		Control rating			
Basagran	0.5 pt	--	G-E	F	--	--
Cobra	6 fl oz	--	G-E	VP	--	--
Extreme	1.5 pt	E	E	G-E	P	P
FirstRate	0.3 oz	E	E	F-E	P-F	F
Flexstar	0.75 pt	E	E	E	E	E
Harmony ¹	0.083 oz	--	P-F	P	--	--
Metribuzin	0.25 lb	E	G-E	F	--	--
Pursuit	2 fl oz.	G-E	E	G-E	P	P
Python	1 oz	F-G	--	--	--	--
Raptor ²	4 fl oz	--	E	E	G	F
Spartan	4 fl oz	P-F	--	--	--	--
Ultra Blazer	0.75 pt	--	F-G	P	--	--
Valor	2.5 oz	G-E	--	--	--	--

¹Harmony (thifensulfuron) will not control volunteer SU canola hybrids.

²Raptor (imazamox) will not control Clearfield canola hybrids.

Note: Liberty Link canola will not be controlled by Liberty in Liberty Link corn or soybean. Liberty will control Roundup Ready canola in Liberty Link corn or soybean.

Volunteer canola control in dry pea.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola
	product/a		Control rating			
Basagran	0.5 pt	--	G-E	F	--	--
Pursuit	2 fl oz	G-E	E	G-E	P	P
Raptor ¹	4 fl oz	--	E	E	G	F
Metribuzin	0.25 lb	E	G-E	F	--	--
Spartan	4 fl oz	P-F	--	--	--	--

¹Raptor (imazamox) will not control Clearfield canola hybrids.

Volunteer canola control in flax.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola	Control rating	
							product/a	-----
Bronate Adv	0.8 pt	--	E	F-G	--	--		
MCPA ester	0.5 pt	P	G-E	P	--	--		
Spartan	4 fl oz	P-F	--	--	--	--		

Volunteer canola control in wheat.

Herbicide	Rate	Pre-emergence	3-leaf canola	6-leaf canola	Bolting canola	Flowering canola	Control rating	
							product/a	-----
Aim	0.5 oz	--	VP	N	N	N		
Bronate Adv	0.8 pt	--	E	F-G	--	--		
Curtail	0.5 pt	--	G-E	F-G	--	--		
2,4-D ester	0.5 pt	--	G	P	--	--		
Dicamba	2 fl oz	--	P	N	N	N		
Express ¹	0.167 oz	--	E	G-E	--	--		
Harmony ¹	0.3 oz	--	E	G-E	--	--		
Huskie	11 fl oz	--	E	G-E	--	--		
MCPA ester	0.5 pt	P	G-E	P	--	--		
Sharpen	1 fl oz	E	E	E	F	G		
Starane	0.5 pt	--	VP	VP	--	--		
WideMatch	0.25 pt	--	P	P	N	N		
Wolverine	1.7 pt	--	E	G-E	--	--		

¹Harmony (thifensulfuron) will not control volunteer SU canola hybrids.

Insect Pest Management

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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	Cutworms	Aphids	Bertha
Diamondback moths	Diamondback moths	Bertha armyworms	armyworms Flea beetles
Flea beetles	Grasshoppers	Blister beetles	Grasshoppers
Grasshoppers	Lygus bugs	Diamondback moths	Lygus bugs
Aster leafhoppers	Aster leafhoppers	Grasshoppers Lygus bugs Aster leafhoppers	

■ Flea Beetles (*Phyllotreta* species)

Coleoptera: Chrysomelidae

The crucifer flea beetle, *Phyllotreta cruciferae*, is the main species of flea beetle that feeds on canola in North Dakota. The striped flea beetle, *P. striolata*, also feeds on canola. Flea beetles have a single generation per year.

Adult flea beetles overwinter in shelterbelts and leaf litter near last year's canola fields. Adults start to emerge as temperatures warm up to 58 F. Populations will emerge slowly with cool temperatures or more quickly with warm temperatures.

The tiny, black crucifer flea beetles are about 1/10th of an inch long with a metallic bluish sheen, and move into the canola fields just as the seedlings are emerging. Striped flea beetles have two yellow stripes on their black wing covers and are comparable to the crucifer flea beetles in size.

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 green pods, stems and leaves for several weeks.

Fortunately, populations of summer flea beetles are rarely 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, 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 next spring.

Pest Management

Insecticides are the most effective control measure for flea beetles. The seedling stage is the most susceptible period, and insecticides are usually applied as a seed treatment prior to planting or as a foliar application to protect the crop from flea beetle feeding injury.

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 (more 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 can be used as monitoring tools to indicate when and how many flea beetles are moving into fields.

If the seed treatment did not provide adequate protection or was not used, an application of a foliar insecticide may be necessary. **Foliar insecticide applications are**

recommended when 20 to 25 percent defoliation occurs on the cotyledons and true leaves and/or first true leaves, and beetles are actively feeding in field.

When flea beetle populations are high during hot, dry weather, populations can increase rapidly and fields can be re-infested due to flea beetle movement. Thus, insecticide seed treatment may not provide adequate protection against flea beetles, and a foliar application must be made quickly for effective pest management.

One of the problems producers face is being able to cover a large acreage quickly when flea beetle populations are high or re-infesting fields. Canola usually can compensate for flea beetle injury once it reaches the four to six true leaf stage.

The development of insecticide resistance in *Phyllotreta* flea beetles is a concern in canola because neonicotinoid insecticide seed treatments have been the primary insecticide used to control flea beetles for more than a decade. In Canada, the striped flea beetles are more tolerant (less mortality) of neonicotinoid seed treatments, compared with the crucifer flea beetles.

Research is underway in North Dakota to determine if neonicotinoid seed treatments still are effective against these two *Phyllotreta* species and if striped flea beetles are becoming more common than crucifer flea beetles in canola.

For more information, consult the NDSU Extension publication "Integrated Pest Management of Flea Beetles in Canola," E1234 (www.ag.ndsu.edu/publications/crops/integrated-pest-management-of-flea-beetles-in-canola/e1234.pdf).

■ 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. The moth 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, drab brown and 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, 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 to capture moths. Traps should be suspended near the crop at the field's edge. Traps provide an early indication of a possible infestation.

The moth 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 injury (blooming to early pod). The third generation usually is too late to cause injury, except in the late-planted canola fields.

If high numbers of adults (greater than 100 moths per trap per 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. After beating plants, count larvae on the ground or dangling from plants on a silk thread. Again, check several locations per field.

For the early flowering stage, insecticide applications may be justified at larval densities of 10 to 15 larvae per square foot (or one to two larvae per plant). The action threshold for canola at the pod stage is an average of 20 larvae per square foot (two to three 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 can affect diamondback moth populations negatively. For example, heavy rain can drown many first-generation larvae. Humid conditions associated with rainfall also can favor the development of fatal fungal diseases such as *Entomophthorales*. Several parasitic wasps and predators (flies, lacewings, minute pirate bugs, spiders and birds) prey on diamondback moth larvae.

For more information, consult the NDSU Extension publication “Diamondback Moth in Canola: Biology and Integrated Pest Management,” E1346 (www.ag.ndsu.edu/publications/crops/diamondback-moth-in-canola-biology-and-integrated-pest-management/e1346.pdf).

■ **Bertha Armyworm** (*Mamestra configurata*)

Lepidoptera: Noctuidae

The adult moth is about 1½ inches long and 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-late June and emergence continues through early August. These night fliers are particularly attracted to blooming canola fields for their nectar and egg-laying sites.

Eggs are laid on the lower side of leaves in clusters of 50 to 500 eggs in a honeycomb pattern and hatch in about one week. The emerging larvae (1/10th of an inch) usually are green. Mature larvae are about 1½ inch 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. The moth 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 economic 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 to 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 or direct combined.

The economic threshold will vary from one to three larvae per square foot. Higher-priced canola will take fewer larvae to reach the economic threshold. The key to controlling bertha armyworm is:

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

For more information, consult the NDSU Extension publication “Bertha Armyworm in Canola: Biology and Integrated Pest Management,” E1347 (www.ag.ndsu.edu/publications/crops/bertha-armyworm-in-canola-biology-and-integrated-pest-management/e1347.pdf).

■ **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; however, 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. 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 or damaged seeds are lost during harvest. In severe outbreaks in Canada, yield losses from bud blasting and seed damage 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, often in high numbers. Use a 15-inch sweep net and make 10 180-degree sweeps at several sampling sites.

The economic thresholds 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 high, control during the early pod ripening stage is usually the most economical.

■ Cutworms

Lepidoptera: Noctuidae

Several species of cutworms feed on agricultural crops in the northern Great Plains, such as dingy cutworm, red-backed cutworm and pale western cutworm. Adult cutworms are moths about 1½ inches long with brown to gray wings, often with dark markings.

Cutworms have one generation per year. They overwinter as eggs or young larvae, depending on the species. 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 each time. A mature cutworm larva is about 1½ inches long and as wide as a pencil.

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 females 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, 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 justify 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 emerge 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 in the pod development stage for adults.

Grasshopper damage is often 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 equals 1 square yard. The infestation ratings are listed below in the table. **A “threatening” rating would indicate a need to treat with an insecticide.**

Rating	Nymphs per square yard		Adults per square yard	
	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 mid-summer 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.

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 10 adult blister beetles per plant are 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 are usually pale green to grayish green and found in large numbers near the top of individual plants. Infested plants often appear shiny from the honeydew they secrete.

Most aphids migrate into North Dakota from southern states, and some may overwinter here. Aphids arrive in canola during late spring. 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 up and become crowded, winged adults are produced and disperse to begin new colonies. Multiple, overlapping generations of aphids occur within a season.

Aphids have piercing-sucking mouthparts that feed on the plant's sap, inhibit terminal growth, stunt plant size and reduce 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 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 larvae or lacewing larvae, are present.

■ **Aster Leafhopper** (*Macrostelus quadrilineatus*)

Hemiptera: Cicadellidae

Aster Leafhopper (also called six-spotted Leafhopper) are greyish leafhoppers. The adults are 1/8 inch long, and have clear wings and six spots arranged in three rows between the compound eyes. Immature leafhoppers or nymphs are small, wingless versions of adults.

Aster leafhoppers migrate into North Dakota from the southern states and usually arrive in mid-May to mid-June. Leafhoppers are active, jumping and flying when temperatures are above 59 F.

The leafhopper uses its piercing-sucking mouthparts to feed on plant sap. The injury caused by aster leafhopper feeding produces localized necrosis or stippling.

Canola and other Brassica species (mustard) are not a preferred host for food and reproduction of aster leafhopper. It prefers to feed on wheat, barley and vegetable plants (lettuce and carrot), grapevines and herbs. Adults may move between host plants and follow what's green and available.

Disease Vectors — These insects may be economically important in canola, but less because of their feeding injury and more because they are the principal vector of Aster yellows. Aster yellows has a very wide host range and causes plant disease and economic losses in several vegetables and ornamentals. Aster yellows is caused by a phytoplasma; an organism similar to a bacterium but without cell walls.

Aster leafhoppers acquire the phytoplasma by feeding on an aster yellow-infected plant for a minimum of 30 minutes. Acquisition of the phytoplasma increases with longer feeding times. The aster yellow phytoplasma requires another two weeks' incubation period within the aster leafhopper before the leafhopper can transmit the disease to new plants.

Consequently, immigrating aster leafhoppers, arriving already infectious, are more likely to vector the disease into fields. However, once it acquires the phytoplasma, a leafhopper remains infectious for an extended period of time. Although the acquisition phase may be long, the leafhopper needs only a very short feeding period to transmit the disease to uninfected plants.

Symptoms of aster yellows in canola take about 21 to 35 days to appear, and sometimes plants are infected but show no symptoms. Flowers are distorted and sterile. Flowering portions of the plant may show excess branching and stunting (shortened internodes), resulting in a “witches broom” appearance. Aster yellow-infected canola plants often are taller than the rest of the plants.

Pods are replaced by inflated round or oval blue-green bladderlike structures. Infected plants produce little seed, but the percent of infected plants is usually quite low (less than 5 percent) most years.

Symptoms on canola can be confused with sulfur deficiency, anthocyanin production (purpling due to crop stress) and growth regulator herbicide damage.

Pest Management

The amount of aster yellows in fields would depend on the number of leafhoppers from local fields and immigrants from southern states, the percent of leafhoppers carrying the aster yellows phytoplasma and the time of arrival of the leafhoppers. Aster leafhoppers may feed on young canola plants at the beginning of the season and then move to grasses and more preferred crops as the canola matures.

Hot and dry conditions are not conducive to the spread of aster yellows. In contrast, abundant rainfall makes plants more succulent, which makes them more attractive to leafhoppers.

To manage aster yellows in canola:

1. Plant early to reduce the incidence of aster yellows by making plants less attractive (more mature) to migrating aster leafhoppers.
2. Control perennial weeds in fields because weeds can be a good source of the aster yellows phytoplasma.
3. Due to the mobility of aster leafhoppers, any insecticide spray program would be a “hit or miss” situation. Leafhoppers move around from field to field and crops to crops, and preventing aster yellows from being vectored would be difficult. As in wheat and barley, no economic threshold has been established in canola.
4. We also do not know how often we would need to spray. The residual of most pyrethroid insecticides is seven to 10 days. However, the economics of multiple

and frequent foliar insecticide applications is not practical in canola as it is in high-value vegetable crops.

5. In addition, flowering canola is a major source of honey for honey bees in North Dakota, and any insecticides sprayed during flowering would be deadly for honey bees. We recommend not spraying insecticides on flowering canola to protect pollinators, and only spraying insecticides when bertha armyworms or other insect pests are at economic threshold levels in fields. If foliar-applied insecticides are necessary during flowering, spray in the early morning or late evening, when bees are not actively foraging.
6. Research conducted in snap beans and okra suggests that the neonicotinoid seed treatments should be effective in reducing leafhopper infestations in canola for up to 30 days.

INVASIVE INSECT PEST OF CANOLA (not in North Dakota as of 2018)

■ Swede Midge *(Contarinia nasturtii)*

Diptera: Cecidomyiidae

Swede midge is an invasive insect pest from Europe and Asia that was introduced into North America in Ontario, Canada, in 2000, and then first was found in the U.S. in 2004 in New York. It quickly spread in Canada into Quebec in 2003, Nova Scotia and Saskatchewan in 2007, and Prince Edward Island and Manitoba in 2008.

In the U.S., it occurs primarily in the northeast, including Connecticut, Massachusetts, New Jersey and Vermont.

In 2014, swede midge was captured in pheromone traps near Winkler, Manitoba, which is close to the North Dakota border (just north of Walhalla), and near the major canola production area of northeastern North Dakota.

As result of this positive detection, NDSU Extension has conducted pheromone trap surveys for swede midge in 2015, 2017 and 2018 in the major canola production areas of North Dakota. Results of the trap surveys are all negative for swede midge in North Dakota so far.

The swede midge adult is a small brown fly about 1/16 inch long with sparse venation on wings. Swede midge is difficult to identify without a microscope and taxonomic expertise because of its small size and similarity to other midges.

The antennae and wing venation of swede midge are two characteristics used for identification. Antennae of males are distinctive, consisting of 12 antennal segments, each with two beadlike “nodes” separated by more slender, stemlike connections. Larvae are cream to yellow, and only about 1/16 inch long when mature.

Hosts of the swede midge include a wide range of species within the family Brassicaceae (or Cruciferae), and include the following: canola (*Brassica napus*, *B. rapa*), broccoli (*B. oleracea* var. *italica*), cauliflower (*B. oleracea* var. *botrytis*), cabbage (*B. oleracea* var. *capitata*), radish (*Raphanus sativus*) and cruciferous weeds (for example, wild mustard, field pennycress, wild radish).

Swede midge overwinter as pupae in the soil of canola fields and other hosts. In the northern Plains, three overlapping generations per year are common, with the first emergence of the overwintering generation occurring in late May and peak emergence in June. The second, or summer generation, emerges mid-July to early August, and

the third generation emerges during late August into early September. The complete life cycle takes from 20 to 80 days.

Adults emerge in the spring from the puparium in the soil, and only live one to five days. Females lay 15 to 50 eggs in clusters on the youngest parts of the plant, such as flower buds or leaf stalk bases. Larvae emerge from the egg after three to 10 days. Larvae feed on plant tissue for two to three weeks, then jump or drop to the ground and spin cocoons in the top ½ inch of soil for pupation. The next generation of adults, except for the overwintering generation, will emerge two weeks later.

Swede midge can cause significant yield loss to canola plants during wet, warm weather, which allows the swede midge to emerge earlier, and increases its survival and ability to produce multiple generations. Adults only feed on nectar of flowering plants and do not damage the canola plant.

However, larvae secrete salivary fluids that are toxic to the plant causing abnormal growth and brown scarring of plant tissue (for example: deformed, twisted leaves or malformed growing points on the plant), gall formation and fused flowers that produce no pods. Damage easily can be confused with mechanical damage, heat or cold stress, fertility issues or herbicide damage.

Pest Management

For early detection of swede midge in canola grown in North Dakota, growers should monitor fields with pheromone traps and report any suspicious damage to Extension agents and/or specialists. The Jackson trap and pheromone lures are available commercially for swede midge monitoring from insect trap suppliers (for example, Great Lakes IPM).

Traps are placed low, about 12 inches above the ground, and at field edges from June through maturity. Check traps at least weekly and send any suspect midge samples to NDSU Extension Entomology or the NDSU Plant Diagnostic Laboratory for identification.

Although insecticides are registered for canola, control of swede midge is problematic due to its multiple overlapping generations that could infest canola throughout the season. Insecticide applications need to focus on peak adult populations based on pheromone trap monitoring, and preventing egg laying. No trap economic threshold has been established for monitoring swede midge in canola.

A cultural control strategy is early planting to ensure the crop is growing actively and vigorously by the time adult populations peak. Fall tillage of volunteer canola and cruciferous weeds also can help reduce overwintering populations. Because swede midge is a weak flyer, planting new canola fields about $\frac{1}{2}$ mile away from previously infested fields can help lower infestation levels. However, this does not work well in areas with a high density of canola fields in major production areas.

Parasitoids and predators (for example, parasitic wasps, spiders, ground beetles) that attack swede midge have been recorded in Canada and may help reduce pest populations to some extent. Dry, cool weather also can limit population growth and range expansion, whereas moist, warm weather favors its development.

>>> Protect Pollinators When Spraying Insecticides to a Blooming Canola Field <<<

Bees are in trouble in the U.S. and other areas of the world. Native bee species are declining in numbers due to habitat loss, pesticides and other factors. Approximately one-fourth to one-third of European honey bee colonies in the U.S. die each year despite the best efforts of their attentive beekeepers.

Canola is a very attractive and nutritious food crop for bees, especially honey bees. The nectar of canola has good sugar content that produces high-quality honey, and its pollen contains a good balance of amino acids and proteins for bee health. With nearly 1.6 million acres of canola grown each year in North Dakota, canola plays a key role in bee health.

Another benefit of canola is that it extends bee foraging because canola fields bloom for relatively long periods of three to four weeks. Consumers also demand the light-colored, mild-tasting honey that canola produces. Research on the pollination benefits of honey bees in canola has found a 13 to 46 percent increase in yield when hives were present, compared with the absence of hives.

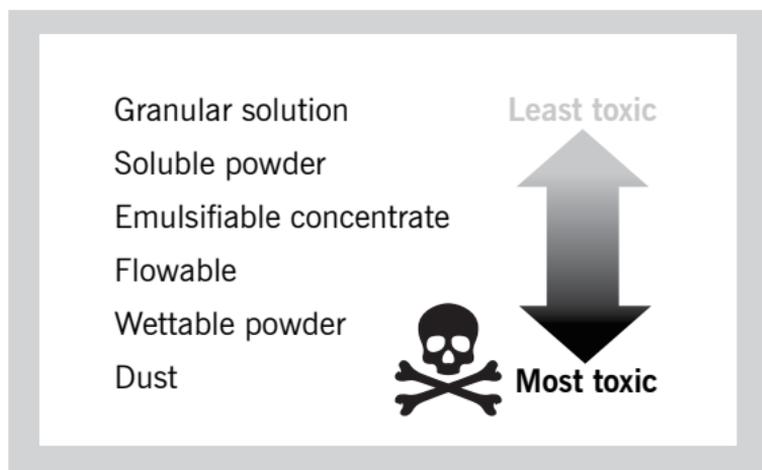
An integrated pest management (IPM) approach should be used to promote the judicious use of pesticides only when needed and to implement scouting, use of economic thresholds and nonpesticide pest management strategies, such as cultural, biological control or host plant resistance.

Most of our insecticides used in canola are broad-spectrum insecticides. Any broad-spectrum insecticide will kill all insects, including bees and natural enemies of the targeted

insect pest. If insecticides need to be applied to blooming canola for insect pest management, choose the least hazardous formulation of an insecticide product for bee safety, and use short-residual insecticides. If possible, spot treat to minimize the area treated with insecticide, especially for edge insect pests such as young grasshoppers that do not move very far from their egg hatching sites in road ditches.

The best time to apply an insecticide to minimize bee kill is in the late evening (after sunset) or during cooler temperatures. Most bees are not foraging actively when temperatures are below 55 F. However, some bees, such as bumblebees, forage in cooler temperatures (as low as 50 F) and thus forage much longer than honey bees.

Pesticide formulations and general toxicity to bees.



Always read, understand and follow the pesticide's label directions in regard to pollinator protection. Some pesticide labels require pesticide applicators to notify beekeepers 48 hours prior to applications to blooming crops (or if flowering weeds are present in fields).

Pesticides that have the honey bee hazard icon (on right) on the label indicate that this product is highly toxic to bees and specific application restrictions apply to protect pollinators.



Finally, know and communicate with your local beekeepers if you need to spray flowering canola fields for control of insect pests. Honey bee colonies should be protected from insecticide applications by notifying beekeepers *before the application* (at least a 48-hour notice) so they can move or cover their hives.

To locate beekeepers, see the **North Dakota Bee map** (beemap.ndda.nd.gov/map) on the North Dakota Department of Agriculture website. Zoom in on the area of interest to find names and contact information of local beekeepers. Also see the “North Dakota Pollinator Protection Plan” from the North Dakota Department of Agriculture (www.nd.gov/ndda/sites/default/files/legacy/resource/ND%20Pollinator%20Plan%202016.pdf).

Insecticides

Please consult the current “North Dakota Field Crop Insect Management Guide,” E-1143 (www.ag.ndsu.edu/publications/crops/north-dakota-field-crop-insect-management-guide) for the most updated list of insecticides that are registered for control of insect pests in canola.

Disease Management and Control

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Diseases of canola can threaten crop yield throughout the growing region. The cause and importance, signs and symptoms, survival and spread, and management tools of several diseases will be discussed, including:

- Alternaria black spot
- Aster yellows
- Blackleg
- Clubroot
- Downy mildew
- Fusarium wilt
- Root rots
- Sclerotinia stem rot (white mold)
- White rust (staghead)

Two diseases, Blackleg and Sclerotinia stem rot (white mold), are the primary yield-threatening diseases in North Dakota. Both diseases are widespread in the growing region and have a history of causing yield loss. We will focus heavily on these primary diseases and include information about the Sclerotinia Risk Map, Risk Calculator and Sclerotinia Checklist.

Photographs of select diseases are found
in the back of this field guide.

General Disease Management Principles

Diseases can occur at any time during the growing season. The most effective disease management strategy begins long before the canola is seeded and continues after harvest. Below are keys to effective disease management in canola:

- **Crop rotation** – Most diseases in canola are more likely to occur, and more likely to be severe, if short crop rotations are used. Lengthening crop rotation allows the natural biological processes that take place in a field to reduce the level of many pathogens and reduce the likelihood of yield loss.
- **Hybrid selection and genetic resistance** – Each hybrid may have a different level of resistance or tolerance to many of the important diseases in canola. Careful selection of hybrids resistant to important diseases in your field can be a cost-effective way to help manage diseases.
- **Hybrid rotation** – Many pathogens are highly variable in nature and can become resistant quickly if a hybrid with the same genetics is used repeatedly. Using a diversity of hybrids reduces this risk.
- **Fungicides** – Effective use of fungicides can help prevent diseases. This includes fungicides applied as seed treatments or foliar-applied. Optimization of foliar fungicides, including application coverage (water, nozzles, etc.) and timing is just as, or more important as the selection of the fungicide.
- **Scouting** – Scouting is the key to identifying an epidemic in progress, optimizing fungicide timing (in some cases) or identifying a new or emerging disease problem.

- **Stay up to date** – Disease management tools and the knowledge to use them are improving continually. Seek knowledge to utilize improved management strategies.

■ **Alternaria Black Spot**

Cause

Alternaria brassicae and *Alternaria japonica*

Signs and Symptoms

Spots may develop at any time during the growth of the plant; however, they are more likely to occur during or after flowering and may be produced on leaves, branches and pods. 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 *B. napus* (Argentine canola) than in *B. rapa* (Polish canola). 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 pod production 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 and combine as soon as possible.

■ Aster Yellows

Cause

Candidatus phytoplasma asteris

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 and 2012, when infection was noticeable in many fields in North Dakota and Minnesota, and economic losses occurred in a few fields.

Survival and Spread

The aster yellows phytoplasma does not survive the winter in North Dakota or Minnesota. It is transmitted by the aster leafhopper, *Macrostelus fascifrons*. The incidence 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 rarely causes economic loss. Early planting may reduce the incidence of aster yellows.

■ Blackleg

Cause

Blackleg is caused by two fungal pathogens, *Leptosphaeria maculans* and *L. biglobosa*. *Leptosphaeria maculans* is highly aggressive and is the predominant cause of blackleg in North Dakota and Minnesota. In contrast, *L. biglobosa* is less damaging than *L. maculans*, and it is found in North Dakota and Minnesota infrequently.

The *L. maculans* pathogen can produce races that differ in their virulence to specific canola hybrids. These race isolates are classified as PG2, PG3, PG4 and PGT. In the 1990s, *L. biglobosa* was considered a mild-affecting race of *L. maculans* and was named PG1. However today, *L. biglobosa* is recognized as a distinct species but still can be referred to as PG1. Blackleg races predominant in the region can infect cultivars carrying resistance genes *Rlm1*, *Rlm2* and *Rlm3*; isolates classified earlier as belonging to PG4 share this ability.

Signs and Symptoms

Blackleg can affect canola plants throughout their life cycle; however, economic losses occur mainly when initial infections take place before the plant reaches the four- to six-leaf stage. Earliest infection by the blackleg pathogen often is observed on cotyledon leaves as round to irregular-shaped lesions with a tan or buff color.

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. On true leaves, lesions may be surrounded by a yellow halo.

Once pycnidia start forming, hyphae from the fungus grow inside the plant tissues toward the stem and then downward toward the crown. This growth occurs mostly without causing any visible symptoms. When plants approach the flowering stage, stem lesions become evident as sunken gray to dark gray areas that may be surrounded by a dark or black border.

Pycnidia frequently are produced in the center of stem lesions. As lesions enlarge, they 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 as pycnidia or mycelium on infected crop residues. In the spring, during wet weather, pycnidia release a gelatinous ooze containing pink asexual spores called “conidia” that are dispersed by rain. The conidia are responsible for localized spread of the blackleg fungus, resulting in “hot spots” of infection.

In addition, the blackleg pathogen can produce pseudothecia, fruiting structures that produce sexual spores called “ascospores” on these residues. 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.

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 flea beetle activity, especially during the seedling stage, 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 may 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 different resistant hybrids to extend the shelf life of resistant genes currently

available. Continuously utilizing the same resistant hybrid may speed up the development of races capable of infecting them.

We encourage growers to submit blackleg-infested canola stubble to qualified laboratories for identification of races present and then use that information to select hybrids with the appropriate resistance.

Crop rotation – Because the blackleg pathogen survives in crop residue for multiple years, we recommend a four-year crop rotation to most effectively manage the disease. In addition to reducing disease pressure, a longer crop rotation will reduce the likelihood that new races develop.

Disease-free seed – Plant certified disease-free seed. This is especially important when seeding canola in a new field.

Seed treatment fungicides – Numerous fungicide seed treatments are registered for blackleg control 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 PP622) when selecting a fungicide seed treatment.

Foliar fungicides – Take economics and disease risk into consideration before applying a foliar fungicide. High-risk factors for blackleg include a susceptible or moderately susceptible hybrid, the known occurrence of virulent races of the blackleg pathogen or a tight crop rotation. Fungicide trials demonstrated that a single fungicide application was able to reduce disease and provide some yield protection in susceptible hybrids but that foliar fungicides did not give adequate control.

If utilized, foliar fungicides should be applied at the two- to four-leaf stage. Further, because many foliar fungicides

registered to manage blackleg have the same active ingredient as the seed treatments available, consider applying foliar fungicides with different modes of action than those in the seed treatment. Consult the “North Dakota Field Crop Fungicide Guide” (Extension publication PP622) 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 the publication “Blackleg of Canola,” (PP1367) and additional information and photographs can be found in that publication.

Fungicide information can be found in the publication “Field Crop Fungicide Guide” (PP622).

■ Clubroot

Clubroot is a destructive disease of many crops in the canola (Brassica) family. In 2013, it first was detected in seven canola fields in Cavalier County, N.D. By 2018, at least 25 known fields were infected. Clubroot is a serious threat to canola production and is likely to be spread to new fields in the future.

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. Areas of poor plant growth may develop and should be investigated thoroughly at the end of the season for clubroot.

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 via soil movement, including soil on equipment, and wind and water erosion. Commonly, this includes movement of soil from field to field during cultivation.

Disease Management

No satisfactory management exists. High pH soils are less conducive to clubroot than acidic soils. In acidic soils, liming with beet lime may reduce severity temporarily.

In North Dakota, the primary mechanism of spread has been through infested soil carried on farming equipment. Avoid introducing soil from infested areas. Always work the clubroot-infested fields last and sanitize your farm equipment after working in clubroot-infested fields.

Although on a yearly basis, the inoculum density is reduced by 50 percent, we recommend producers practice longer crop rotations. Resistant hybrids are available, but judicious use of that resistance will help prolong the effectiveness of the resistance; seeding the same cultivar not more than twice in a five-year period is strongly recommended.

The clubroot pathogen also is known to occur in British Columbia; Alberta; parts of Saskatchewan, Manitoba and Wisconsin; and eastern U.S. and Canada. Farm equipment obtained from those regions should be sanitized before use in North Dakota.

The clubroot pathogen also affects radish, broccoli, cauliflower, cabbage, rutabaga, Chinese cabbage, turnip and arugula, so use caution when using these plants in

your crop rotation (for instance in a cover crop mixture) or planting them in your garden. Good weed control is important because clubroot also can infect (and survive on) wild mustard, shepherd's purse, field pennycress and other brassica weeds.

■ Downy Mildew

Cause

Hyaloperonospora parasitica

Signs and Symptoms

A white, mealy growth develops on the lower surfaces of leaves. The upper leaf surface opposite the infected area turns yellow and could die. Symptoms can develop early in the life of plants and can continue after the canopy has closed; however, under North Dakota and Minnesota conditions, it rarely progresses above the third or fourth true leaves.

Survival and Spread

The downy mildew fungus is favored by cool, moist weather. It may occur in association with white rust in other regions of the world, and the disease complex usually would be more serious than either disease alone; however, in North Dakota, white rust is not considered a problem.

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.

■ Fusarium Wilt

Cause

Fusarium oxysporum f.sp. *conglutinans*

Signs and Symptoms

The disease can be observed at almost any growth stage of the plants. 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

The pathogen can survive in the soil as chlamydospores for several years in the absence of a host, but it also can survive infecting cruciferous weeds. 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 *B. rapa* (Polish canola) 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 North Dakota or Minnesota.

■ 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 available in the past.

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. sclerotiorum* 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

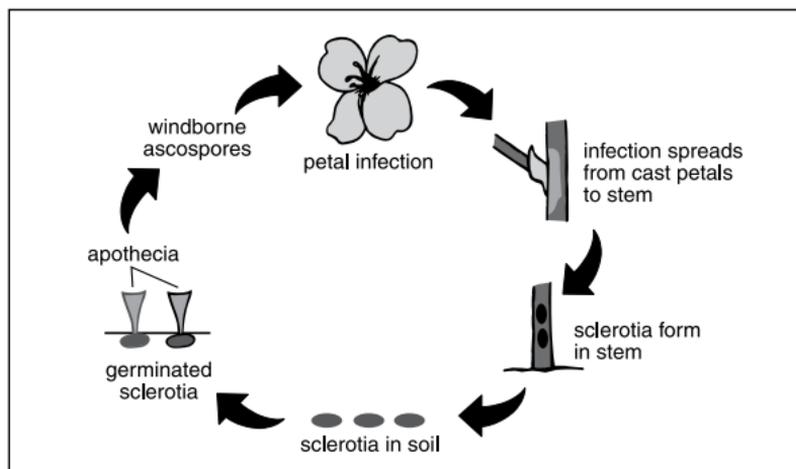
The pathogen produces sclerotia (resting structures) in infected stems. Sclerotia fall to the ground during harvest, and they can survive on or in the soil for many years. After the sclerotia have overwintered, 1 to 2 inches of rain in a one- to two-week period will moisten soil enough for sclerotia 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 dispersed 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 48 hours or more 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),



Sclerotinia Disease Cycle

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 hybrids are susceptible to some degree. However, some cultivars may be less susceptible than others.

Biological control – The fungus *Coniothyrium minitans* (sold commercially as Contans WG) can attack and kill sclerotia in the soil. Research conducted at Carrington, N.D., showed that fall application of Contans was effective in reducing viability and vigor of sclerotia. Contans may be of greatest use under high disease pressure or when using cropping practices such as irrigation. Another biocontrol product registered for use in North Dakota (sold commercially as Serenade ASO) is *Bacillus subtilis* strain QST 2808. Serenade ASO is labelled for spray or fungigation application. Additional biocontrol products likely will become available. Consult the most current “North Dakota Field Crop Fungicide Guide” (PP622) for more information.

Fungicides – Numerous fungicides with diverse modes of action 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” (PP622). 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/research-extension-centers.

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**, **Sclerotinia Risk Calculator** and **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 more than 90 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 hybrid), 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/.

Sclerotinia Risk Calculator — The Risk Calculator is an interactive tool that produces field-tailored estimations of risk using information such as the fields' nearest NDAWN station, crop rotation and history of Sclerotinia diseases.

The Sclerotinia risk map and risk calculator are available at www.northerncanola.com and www.ag.ndsu.edu/sclerotinia/. These tools also are available through the **NDSU Canola Doctor** app for smartphone devices. The app can be downloaded from the Google Play Store or Apple App Store for installation on android and iOS devices, respectively.

If you decide to make a fungicide application, remember that the best time to spray is when the plants are between 30 and 50 percent bloom. Fungicide applications after canola has reached the 50 percent bloom stage usually do not provide an economic return.

Resources and Citations

This information was adapted from the publication "Sclerotinia of Canola" (PP1410), and additional information and photographs can be found in that publication. Fungicide information can be found in the publication "Field Crop Fungicide Guide" (PP622)

Sclerotinia Stem Rot Checklist

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This is an alternative way to estimate the risk of infection by Sclerotinia but could be used in conjunction with the risk map and risk calculator. To estimate the risk, 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

continued

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.

■ White Rust (Staghead)

Cause

Albugo candida

Signs and Symptoms

This disease commonly occurs on *B. rapa* (Polish canola), as well as on brown and oriental mustard (*B. juncea*), and is of no economic importance in North Dakota and Minnesota. 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 *B. napus* (Argentine canola) hybrids are resistant to white rust. Most *B. rapa* (Polish canola) hybrids are susceptible, but a few newer hybrids are moderately

susceptible, moderately resistant or resistant. Do not plant canola on canola if susceptible hybrids are being grown. Control volunteer canola and wild mustard early in the season because the fungus can reproduce on the cotyledons and young leaves.

Swathing and Harvest Management

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

Straight Combining vs. Swathing

Canola can be swathed and then combined or straight combined. Straight combining has become more common and 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.

Diquat and saflufenacil are active ingredients labeled for use as a preharvest desiccant in canola. Glyphosate is labeled as a preharvest herbicide. Growers can maintain excellent canola yield and quality if the desiccation application is timed properly and the crop harvested in a timely manner.

Desiccants should be applied when 90-plus percent of the seeds have the mature color. Canola seeds mature in the bottom pods first, while the last seeds to mature are in the top pods. Research has shown that when the desiccation 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, desiccants applied too early could result in lower yield and seed quality, with a trend toward higher green content. 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. The preharvest interval is seven or three days for diquat and glyphosate or saflufenacil, respectively. Do not apply saflufenacil or glyphosate to canola grown for seed because reduced seed germination and/or vigor may occur.

Swathing

Swathing canola at the optimum stage of ripening reduces green seed problems and shatter losses, and ensures the quality required for top grades and prices. Inspect fields every two to three days when color change starts to occur 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.

Swathing without a negative effect on yield or seed quality can start when about 60 to 70 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 turn color, seeds in the top, last-formed pods are filled or nearly filled and still green.

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 hybrid. 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. Early 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 the 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 *B. napus* (Argentine canola) at 15 percent seed color change. *B. rapa* (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 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. The 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 (about 80 percent mature seed color), will result in fluffy windrows susceptible to blowing and increased shattering. To reduce shattering losses, overripe fields should be swathed when humidity is high, such as after a rain or heavy dew, or at night.

Swathing Unevenly Maturing Crops

Determining when to swath unevenly maturing fields is difficult. When checking uneven stands, a producer should do an early count on the ratio of early emerged canola, which is bolting or starting to flower, to the late-emerged flush of young, more immature plants. Knowing the ratio of early to late-emerged canola plants allows producers to make a better decision on 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 until 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 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 deficiency will not mature evenly.
- Take soil samples for a general indication of N, P and K.
- 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 occurs.

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, 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 estimated 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. Maintaining oil quality is dependent on keeping storage temperature cool.

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 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 rate 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 canola stored aerobically in grain bags, 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.

Moisture (percent)	Temperature F				
	80	70	60	50	40
	----- Days without clumping -----				
17	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 it all has been cooled uniformly to the average outdoor air temperature. Then it should be cooled whenever average outdoor temperatures are 10 to 15 F cooler than the canola.

Cool canola to about 20 to 35 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 small grains.

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 *B. napus* (Argentine canola) is about twice that of wheat, and for *B. rapa* (Polish 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 cubic feet per minute per bushel (cfm/bu) in a 36-foot-diameter bin filled 24 feet deep with *B. napus* (Argentine canola), you would need a 4.5-horsepower fan operating at 4.4 inches of static pressure.

The *B. napus* (Argentine) is the most common type of canola grown. Obtaining that same airflow rate through *B. rapa* (Polish) 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 *B. napus* (Argentine canola), an airflow rate of 0.23 cfm/bu is obtained. However, if the same fan is placed on the bin of *B. rapa* (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.

Static Pressure (inches of water)	Airflow Rate (cfm/bu)	
	0.75	1.0
	----- 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.

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

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.

U.S. Grades	1	2	3
Grading Factors maximum percent limits of:	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 admixture¹			
Ergot	0.05	0.05	0.05
Sclerotia	0.05	0.10	0.15
Stones	0.05	0.05	0.05
Total	1.0	1.5	2.0
Inconspicuous admixture²			
	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, sclerotia 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 *Brassica juncea*), domestic brown mustard (*Brassica juncea*), yellow mustard (*Brassica hirta*) and seed other than the mustard group.

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

Source: Federal Grain and Inspection Service, USDA.

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www.ag.ndsu.edu/extension/directory

Complete list of NDSU Research Extension Centers
www.ag.ndsu.edu/extension/directory/arearec

Useful Websites

North Dakota State University

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

NDSU Extension canola publications
www.ag.ndsu.edu/crops/canola

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

Canola Insects Information
www.ag.ndsu.edu/extensionentomology/field-crops-insect-pests/canola

Minnesota Agricultural Experiment Station

Hybrid Trial Results - Canola
www.maes.umn.edu/publications/field-crop-trials/canola

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Toll free: 866-834-4378

Web address: www.canolacouncil.org/

Other Resources

Manitoba Department of Agriculture and Food

Web address: www.gov.mb.ca/agriculture/crops/crop-management/canola.html

Canola Growers Manual, Canola Council of Canada

Web address: www.canolacouncil.org/crop-production/canola-grower's-manual-contents

CANOLA – Agronomy



Early season sulfur deficiency.
(NDSU Extension)



Late-season sulfur deficiency.
(NDSU Extension)



Various pod maturity.
(NDSU Extension)



Seed maturity.
(NDSU Extension)



Swather with cutter bar.
(NDSU Extension)



Canola in the swath.
(NDSU Extension)

CANOLA – Weeds



Barnyard grass.
(NDSU Extension)



Biennial wormwood seedling.
(NDSU Extension)



Black night shade seedling.
(NDSU Extension)



Biennial wormwood adult.
(NDSU Extension)

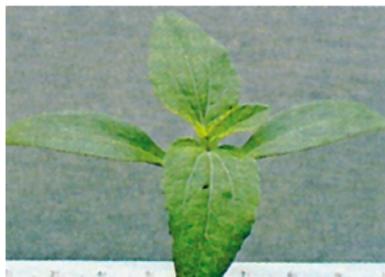


Black night shade.
(NDSU Extension)

CANOLA – Weeds



Canada thistle seedling.
(NDSU Extension)



Cocklebur.
(NDSU Extension)



Common mallow.
(NDSU Extension)



Common ragweed.
(NDSU Extension)



False chamomile adult.
(NDSU Extension)



False chamomile flowers.
(NDSU Extension)

CANOLA – Weeds



Field bindweed. (NDSU Extension)



Field pennycress bolted.
(NDSU Extension)



Fixweed adult. (NDSU Extension)



Green foxtail. (NDSU Extension)



Horseweed marestail immature.
(NDSU Extension)



Horseweed in field. (NDSU Extension)

CANOLA – Weeds



Kochia. (NDSU Extension)



Lambsquarters. (NDSU Extension)



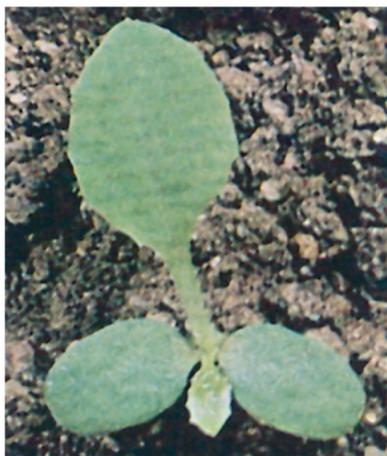
Marshelder. (NDSU Extension)



Night shade adult. (NDSU Extension)



Pennsylvania smartweed.
(NDSU Extension)



Perennial sowthistle.
(NDSU Extension)

CANOLA – Weeds



Pigweed. (NDSU Extension)



Russian thistle. (NDSU Extension)



Shephardspurse rosette.
(NDSU Extension)



Shephardspurse bolting.
(NDSU Extension)



Wild buckwheat. (NDSU Extension)



Wild mustard. (NDSU Extension)

CANOLA – Weeds



Wild oat. (NDSU Extension)



Wild sunflower. (NDSU Extension)



Yellow foxtail. (NDSU Extension)

CANOLA – Insects



Adult crucifer flea beetle, *Phyllotreta cruciferae*.

(P. Beauzay, NDSU)



Adult striped flea beetle, *Phyllotreta striolata*.

(P. Beauzay, NDSU)



Canola seedlings damaged by flea beetle feeding (top) and undamaged seedlings (bottom). (J. Knodel, NDSU)



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



Larvae of diamondback moth.

(Courtesy C. Gorsuch, Clemson University, USDA Cooperative Extension Slide Set Series)



Damage from diamondback moth larvae (aborted flowers).

(J. Knodel, NDSU)

CANOLA – Insects



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



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



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



Nymph of tarnished plant bug,
Lygus lineolaris.
(S. Bauer, ARS, USDA)



Adult tarnished plant bug, *Lygus*
lineolaris. (S. Bauer, ARS, USDA)

CANOLA – Insects



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



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



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



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



Adult two-striped grasshopper, *Melanoplus bit vittatus*. (J. Knodel, NDSU)



Grasshopper nymph.
(P. Beauzay, NDSU)

CANOLA – Insects



Adult Nuttall's blister beetle, *Lytta nuttalli*. (J. Kramlich, NDSU)



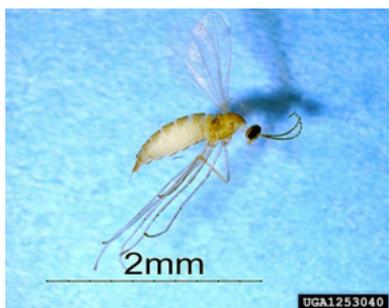
Gray blister beetle.
(A. Spelhaug, Peterson Farms Seed)



Mustard Aphid, *Lipaphis erysimi*.
(A.N. Sparks, Jr. University of Georgia, Bugwood.org)



Aster leafhopper, *Macrosteles quadrilineatus*. (W. Cranshaw, Colorado State Univ., Bugwood.org)



Swede midge, *Contarinia nasturtii*.
(S. Ellis. USDA APHIS PPQ)



Swede midge damage to pods.
(Canola Council of Canada)

CANOLA – Diseases



Alternaria black spot. (NDSU)



Blackleg stem lesion.
(L. Del Rio-Mendoza, NDSU)



Aster yellows plant.
(S. Markell, NDSU)



Aster yellows (close up).
(S. Markell, NDSU)

CANOLA – Diseases



Blackleg on cotyledon leaf.
(L. Del Rio-Mendoza, NDSU)



Blackleg foliar lesion.
(L. Del Rio-Mendoza, NDSU)



Blackleg foliar lesion.
(S. Markell, NDSU)



Blackleg on stem.
(L. Del Rio-Mendoza, NDSU)



Blackleg on stem crowns.
(L. Del Rio-Mendoza, NDSU)



Blackleg on canola pods.
(L. Del Rio-Mendoza, NDSU)



Blackleg stem lesion.
(S. Markell, NDSU)

CANOLA – Diseases



Clubroot. (L. Del Rio-Mendoza, NDSU)



Fusarium wilt. (NDSU)



Rhizoctonia root rot. (NDSU)



Rhizoctonia root rot on young plant.
(L. Del Rio-Mendoza, NDSU)



Sclerotinia stem rot.
(S. Markell, NDSU)



Sclerotinia stem rot.
(L. Del Rio-Mendoza, NDSU)

CANOLA – Diseases



Sclerotia and shredded stem.
(S. Markell, NDSU)



**Sclerotinia sclerotiorum
apothecia.** (S. Markell, NDSU)

White rust (staghead).
(NDSU)



Downy mildew.
(L. Del Rio-Mendoza, NDSU)



Downy mildew.
(S. Markell, NDSU)

Notes

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