K-STATE
Research and Extension

Great Plains Canola Production Handbook

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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U.S. Canola Association

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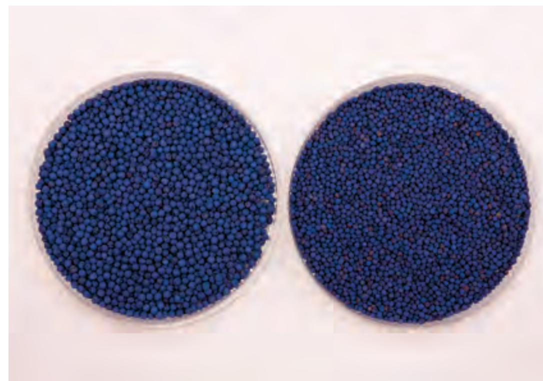

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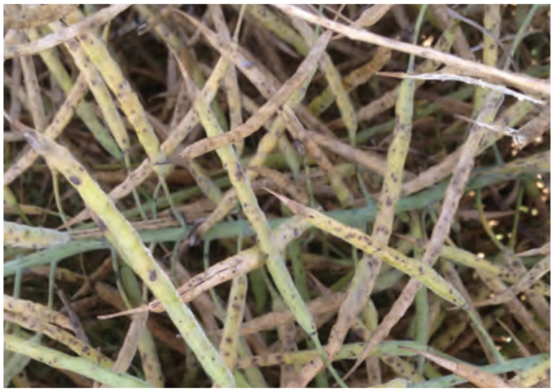

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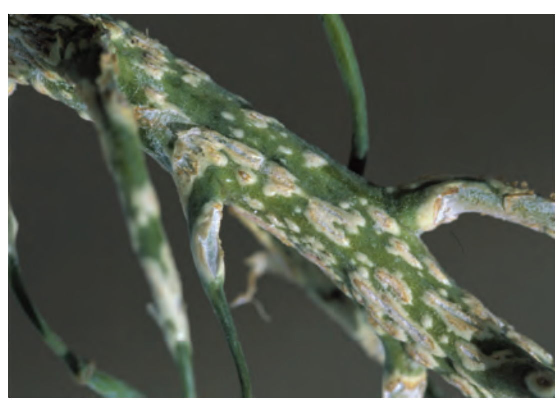

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Summary

Canola is a type of edible rapeseed genetically low in erucic acid and glucosinolates. The seeds are a source of healthy cooking oil and high-protein meal for livestock (Photo 1). A growing number of winter-hardy varieties, suitable for the southern Great Plains, are commercially available. This publication discusses aspects of canola production including field and variety selection, seeding rates, stand establishment, crop growth and development, fertility, weed, insect, and disease management, harvest, grain storage, cost-return projections, and insurance.

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Introduction

Canola is a type of edible rapeseed genetically low in erucic acid and glucosinolates. It differs from standard or industrial rapeseed because it has less than 2 percent erucic acid in the oil and less than 30 micromoles glucosinolate per gram of the oil-free meal. These two quality standards allow canola oil to be used as a healthy cooking oil and the meal as a high-quality protein supplement for livestock.

Rapeseed was grown in Europe extensively in the 13th century, but it has been cultivated in Asia for thousands of years. The oil was used in Asia for cooking, but in Europe it was used for lamp oil and lubrication. During World War II, Canada grew millions of acres to be used as a marine lubricant, but production declined as diesel engines replaced steam engines.

Canada began developing rapeseed with low levels of erucic acid in the oil in 1957 to meet the growing demand for cooking oil. Interest in low-erucic-acid-rapeseed increased, and Canadian production reached 1 million acres in 1965. In 1974, the first true canola variety, 'Tower', was released. Tower is low in erucic acid and glucosinolates. The term "canola" — "Can" for Canada and "ola" for oil — was trademarked by the Western Canadian Oilseed Crushers Association in 1978 and is used to describe rapeseed genetically low in erucic acid and glucosinolates. Canola is also known as "double-low" or "double-zero" rapeseed, or oilseed rape in other major growing regions.

Canola-quality seed has been developed in three *Brassica* species. *Brassica napus,* also called Argentine rape, summer rape, winter rape, and Swede rape, is the most common canola grown. Winter canola varieties grown in the southern Great Plains are developed from *B. napus. Brassica rapa,* also called *B. campestris,* Polish rape, summer turnip rape, and field mustard, is grown on only limited acreage. Canola-quality brown mustard (*Brassica juncea*) has been developed over the past few years, but all *B. juncea* varieties are spring types.

In 1985, the U.S. Food and Drug Administration conferred "generally recognized as safe" status to rapeseed oil containing less than 2 percent erucic acid. One year later, the American Heart Association recommended reducing saturated fat intake. This increased demand because canola oil contains 7 percent saturated fat, the lowest level of any conventional cooking oil. In 2006, the U.S. Food and Drug Administration authorized products containing canola oil to bear a qualified health claim stating canola oil has the ability to reduce the risk of coronary heart disease when used in place of saturated fat. As a result, numerous U.S. restaurants and food service entities have publicly announced their current or planned use of canola oil as a *trans* fat-free, low saturated fat cooking oil.

A significant demand for canola oil and meal exists in the United States. In 2016, the United States imported 3,956 million pounds of canola oil. From 2007 to 2016, domestic disappearance of canola oil increased from 1,985 to 5,312 million pounds. Nearly 77 percent of the canola meal dispersed in the United States is imported (Oil Crops Yearbook, 2017).

Canola production is increasing to satisfy the growing demand for canola oil and meal. Winter canola is well-suited for the southern Great Plains and shows promise for expanded acreage because of the large amount of monoculture wheat grown in the region. Small-grain and row-crop equipment can be used to plant and harvest canola. According to canola producers in the region, yields of winter wheat following canola have shown a 10 to 25 percent increase compared to wheat following wheat. In some instances where wheat has been grown in monoculture for decades, wheat yields have increased more than 50 percent the first year following canola. Thus, a positive rotational effect is present when including canola in a wheat cropping system.

Both spring and winter types of canola are grown in the United States, but winter canola is best adapted to the southern Great Plains. In general, winter canola has a 20 to 30 percent greater yield potential than spring canola in the region. Spring canola flowers approximately 1 month later than winter canola, but it is harvested only 2 weeks later because of summer heat. This shorter grain-filling period reduces the yield potential of spring canola. Spring canola is also under increased pressure from summer annual weeds and insect pests. Because of these factors, production of spring canola is only recommended for rotations requiring spring planting, primarily in central and southern Texas and parts of the irrigated High Plains.

Benefits of a Wheat-Canola Rotation

Growing wheat has been a traditional farming practice for decades in the southern Great Plains. Over time, a lack of rotation has created numerous production issues that have significantly decreased yield and harvested wheat acres in this region. For example, over the past 3 decades, Oklahoma has abandoned about one million acres of wheat because of weed infestations. Some producers have used summer crop rotations with a winter fallow period to alleviate production problems common to continuous wheat, but in years of severe drought, summer crops often fail.

Considering most of the region becomes hot and dry during the summer months, winter crops like canola may make better rotation options than summer crops like corn and soybean. There are several benefits to a wheat-canola crop rotation.

Weed Control

Given that winter canola is a broadleaf, different herbicide classes help control winter annual grassy weeds that have become difficult or too costly to control with wheat herbicides. Examples include quizalofop (Assure II or Targa), sethoxydim (Poast), or clethodim (Select Max, many generics). In addition, Roundup Ready varieties allow nonselective control of weeds of winter annual grass and broadleaf weeds, and Clearfield hybrids allow the use of Beyond herbicide for winter annual grass control. Most of the winter annual grassy weed species can be reduced by rotating to canola and then planting wheat; however, some weed seeds remain viable in the soil for several years before they germinate. Oklahoma State University research suggests that at least 2 years of effective weed management are needed to achieve satisfactory control of troublesome weeds.

Improve Subsequent Wheat Crops

One of the major benefits of a wheat-canola rotation is the improved yield and quality of the wheat crops following canola. Oklahoma State University has conducted field experiments to evaluate the effects of a wheat-canola crop rotation. In 2005, four trials were established across north central Oklahoma to evaluate the amount of wheat forage produced following canola compared to the amount of wheat forage produced following wheat. The data showed a 32 percent increase in wheat tillers and a 21 percent increase in wheat-forage dry weight following canola (Figure 1). The greater number and weight of wheat tillers produced following canola could increase the amount of beef produced per acre if cattle graze the wheat.

A 3-year trial compared weed control and yield differences of a wheat-canola rotation to continuous wheat. Italian ryegrass was controlled up to 97 percent after 2 years and wheat yields following canola consistently averaged 10 percent greater when compared to continuous wheat (Figure 2).

Market Diversity

Canola is an oilseed; therefore, its commodity price is not tied to the price of cereal grains. Since most producers in the southern Great Plains grow cereal crops, their profit potential relies heavily on the cereal grains market. Producers who diversify their cropping systems by producing both cereal grains and oilseed crops can better withstand the risks associated with fluctuating grain markets. Also, winter canola grain is sold at a time when the market price is peaking before spring canola harvest begins in the northern Great Plains and Canada.

As winter canola acres increase in the region, more options are available for marketing the crop. Regional canola grain buyers provide local marketing options and delivery points. Most canola oil in the United States is used for human consumption, but it also makes an excellent feedstock for biodiesel. Thus, the demand for canola oil is expected to increase.

Profitability

Oklahoma State University and Kansas State University have created enterprise budgets comparing continuous wheat and a wheat-canola rotation. Based on average input costs and current market prices, a wheat-wheat-canola rotation proves to be 51 percent more profitable than continuous wheat in Oklahoma. Grain-only continuous wheat and dual-purpose continuous wheat were less profitable than the wheat-wheat-canola rotation. In south central Kansas, canola is projected to yield a 26 percent

Figure 1. *Comparison of wheat tillers and dry forage after canola (C-W) or wheat (W-W).*

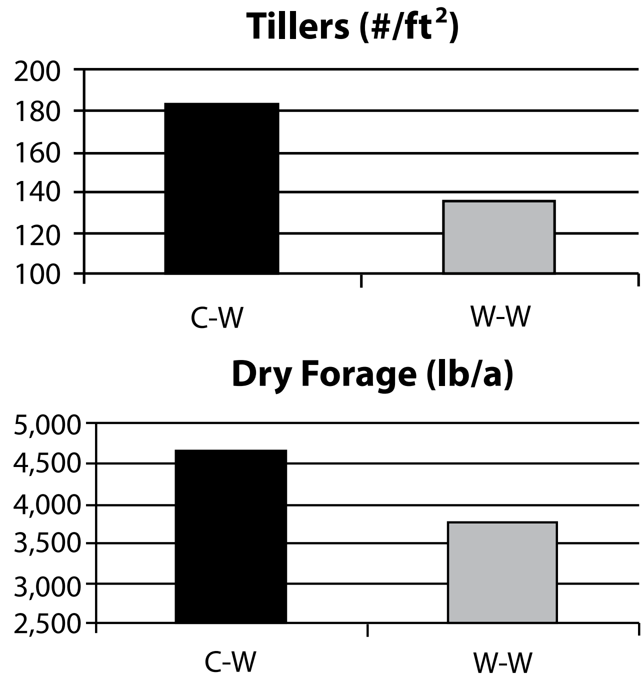
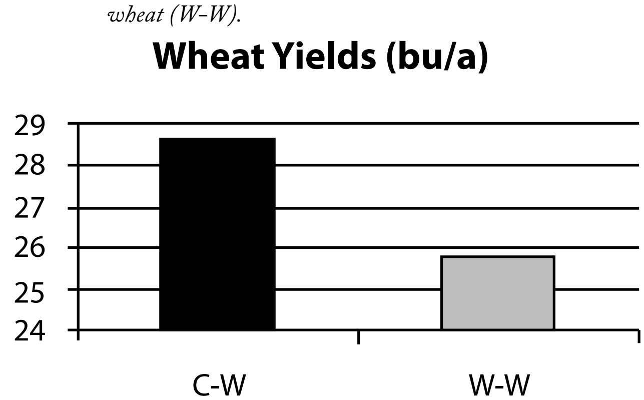


Figure 2. *Comparison of wheat grain yields after canola (C-W) or wheat (W-W).*



return to direct expenses at a 35-bushel-per-acre yield level. These budgets do not include the added benefit of cleaner, higher quality wheat following canola. See page 35 for the Oklahoma State enterprise budget.

Field and Variety Selection

Canola grows best in medium-textured, well-drained soils, but grows over a wide range of soil types. Soil pH between 6.0 and 7.0 is optimal. Yields of most varieties may be reduced significantly where pH is below 5.5. Low pH symptoms will be seen in the fall as crinkled, cupped, or strapped leaves (Photo 2). Canola yields are generally not affected by high pH soils until levels exceed 8.3, at which point high pH soils may accentuate micronutrient deficiencies. Canola does not tolerate waterlogged conditions or fields prone to standing water, flooding, or poor drainage.

Rotation considerations are important when selecting a site for canola production. Several crops grown in the Great Plains have diseases in common with canola. Table 1 lists most of these crops and the recommended time intervals between their production and canola seeding. It is not recommended to plant canola in back-to-back years. A two-year or three-year rotation is best to reduce disease and weed pressures associated with canola production.

Producers should account for weed histories and past herbicide applications when selecting a field. Table 2 lists common herbicides and the required waiting period before canola seeding. Most canola varieties are sensitive to ALS-inhibitor herbicide carryover. Follow all herbicide label directions before seeding canola or any other sensitive crop.

Variety selection is perhaps the most important decision that is made in growing a canola crop. Producers should carefully review variety characteristics and choose varieties that match their management practices. The number of commercial varieties grown in the southern Great Plains is increasing. For information on the latest variety characteristics, see Table 3. Check with local extension offices or local seed dealers for variety performance data and seed availability.

Robust regional and national performance testing systems exist to evaluate experimental and commercial varieties. These systems allow for the dissemination of data necessary to ensure the newest and best-adapted varieties are available to producers. The National Winter Canola Variety Trial is grown at about 40 locations throughout the United States, and the results assist producers with variety selection. Also, Oklahoma State University coordinates variety performance testing across Oklahoma. Information on variety performance can be found at *www.agronomy.k-state.edu/services/crop-performance-tests/index.html* and *canola.okstate.edu/*.

In addition to yield, several traits to consider when selecting a winter canola variety are described in the following paragraphs.

Table 1. *Guide to selection of crops in a rotation with canola.*

Crop	Rotation (years)	Comments
Wheat Oats Barley	0	No diseases in common. Can be grown the year before or after canola. Keep in mind herbicide residue carryover.
Corn Sorghum	0/1	No diseases in common. Zero where herbicide residue is not a concern and one where atrazine is used.
Potatoes Clover Field beans Cotton	1	Common diseases are Rhizoctonia and Fusarium root rots.
Alfalfa Soybeans	2	Common diseases are Rhizoctonia and Fusarium root rots and Sclerotinia stem rot.
Sunflowers	3	Common diseases are Rhizoctonia and Fusarium root rots and Sclerotinia stem rot.

Winter Survival

Successful winter survival depends on the genetics of the variety, the environment in which it is grown, and management practices of the producer (Photo 3). A variety should not be planted unless it consistently survives winter conditions in the southern Great Plains, and conditions affecting winter survival differ across the region. Even though a variety survives well in areas with lower minimum temperatures than those in the Great Plains, it may not tolerate the rapid fluctuations in temperature characteristic of the winter and spring months. Adapted varieties have demonstrated excellent winter survival and performance under stressed and unstressed environments. Before new varieties are marketed, they should show adaptability over multiple locations and years. Varieties have the best chance of surviving if they are planted on time and achieve the optimum amount of aboveground and belowground growth.

Open-Pollinated vs. Hybrid Varieties

One key difference among commercial varieties is that some are open pollinated and others are hybrids. Open-pollinated varieties are pure lines developed through selfing, advancing from one generation to the next. Hybrids are first-generation seed produced from a cross between two or more genetically unique inbred parent lines. The combination of genes results in a hybrid plant that exhibits the most desirable characteristics of the parents and performs better than either parent. The seed cost of hybrid canola is greater than open-pollinated canola because of the costs associated with producing the seed.

Hybrid seed size is usually 30 to 40 percent larger than open-pollinated varieties (Photo 4). In the semi-arid Great Plains, this may not always translate into increased yield, but it may make seeding easier. Because of the larger seed size, hybrids may have an advantage emerging from less than ideal seedbeds. Hybrids may display more vigorous fall growth than open-pollinated varieties, so care should be taken when choosing an optimum planting date. Planting too early may result in too much fall growth and an increased potential for winterkill.

Table 2. *Herbicide restrictions for canola as a rotational crop.*

Herbicide	Crop	Restrictions[1]
Accent	Corn	10 to 18 months
Affinity BroadSpec	Wheat	60 days
Affinity Tankmix	Wheat	60 days
Agility SG	Wheat	22 months or more
Ally	Wheat/Sorghum	Field bioassay required
Ally Extra	Wheat	Field bioassay required
Amber	Wheat	Field bioassay required
Atrazine	Corn/Sorghum	2nd fall following application
Autumn Super	Corn	18 months
Axial XL	Wheat	120 days
Beacon	Corn	18 months
Beyond	Wheat	18 to 26 months[2]
Envoke	Cotton	540 days or field bioassay
Equip	Corn	18 months
Finesse	Wheat	Field bioassay required
Glean	Wheat	Field bioassay required
Hornet	Corn	26 months
Huskie	Wheat/Sorghum	9 months
Maverick	Wheat	Field bioassay required
Olympus	Wheat	Field bioassay required
Olympus Flex	Wheat	12 months or field bioassay[2]
Peak	Wheat/Sorghum	10 to 22 months[2]
Permit	Corn/Sorghum/Cotton	15 months
Prequel	Corn	18 months
Priority	Corn	15 months
PowerFlex	Wheat	9 months
Python	Corn	26 months
Rave	Wheat	Field bioassay required
Realm Q	Corn	10 months
Require Q	Corn	10 months
Resolve Q	Corn	10 months
Spirit	Corn/Sorghum	pH < 7.8, 10 months
Staple	Cotton	Field bioassay required
Steadfast	Corn	10 months
Yukon	Corn/Sorghum	15 months

[1] *Minimum interval between herbicide application and seeding canola. Always refer to herbicide labels for specific information.*

[2] *Rotation intervals depend on geography.*

Yield

In addition to strong genetics, management plays a significant role in attaining high yields. Canola responds favorably to timely and sound management practices. While yield is an important factor in variety selection, do not use it as the only selection criteria. Look for stable, consistent performance over multiple years and locations when evaluating potential varieties for your region.

Oil

Canola varieties grown in the southern Great Plains contain about 40 percent oil. Oil contents can vary by year, environment, and the variety selected. Oil is produced in canola seeds during the later stages of the grain filling period. Typically, hybrids have 1 to 3 percent higher oil content than open-pollinated varieties. Varieties that are adapted and consistently produce over 40 percent oil content should be strongly considered.

Herbicide Resistance

Producers have the option of selecting varieties that are Roundup Ready or Clearfield. To control weeds, Roundup Ready varieties can be sprayed with glyphosate before bolting. Clearfield varieties allow the use of Beyond to control winter annual grassy weeds. Roundup Ready varieties may be an important choice if the main objective is to clean up winter broadleaf weeds.

Sulfonylurea (ALS-inhibitor) Residual Tolerance

Another important variety trait is sulfonylurea residual tolerance. The sulfonylurea class of ALS-inhibitor herbicides is used on a high percentage of winter wheat acres in the region and these herbicides may exhibit residual periods of more than 1 year. The long "plant-back period" excludes canola from the

Table 3. *Commercially available winter canola varieties.*

Name	Distributor	Plant Type[1]	Release Date	Relative Maturity[2]	Herbicide Resistant[3]
HyCLASS115W	CROPLAN by WinField United	OP	2008	ME	RR/SURT
HyCLASS225W	CROPLAN by WinField United	OP	2014	M	RR/SURT
CP320W	CROPLAN by WinField United	OP	2017	E	RR
46W94	DuPont Pioneer	HYB	2011	M	RR
Griffin	Kansas State University	OP	2011	M	---
Riley	Kansas State University	OP	2010	M	---
Torrington	Ohlde Seed Farms	OP	2016	M	---
Hekip	Photosyntech	OP	2014	ME	---
Quartz	Photosyntech	OP	2015	M	---
Edimax CL	Rubisco Seeds LLC	HYB	2012	M	CL
Hornet	Rubisco Seeds LLC	HYB	2007	M	---
Inspiration	Rubisco Seeds LLC	HYB	2014	M	---
Mercedes	Rubisco Seeds LLC	HYB	2014	M	---
Popular	Rubisco Seeds LLC	HYB	2016	ME	---
Claremore	Spectrum Crop Development	OP	2011	F	IMI
Surefire	Spectrum Crop Development	OP	2017	F	SURT
Star 915W	Star Specialty Seeds	OP	2014	M	RR/SURT
Star 930W	Star Specialty Seeds	OP	2017	ME	RR

[1]*HYB=hybrid, OP=open pollinated.*

[2]*E=early, ME=medium-early, M=medium, F=full.*

[3]*RR=Roundup Ready, SURT=sulfonylurea residual tolerant, CL=Clearfield, IMI=imidazolinone residual tolerant.*

crop rotations of many wheat producers. Varieties possessing this trait can be safely planted in the fall following application of these herbicides, making canola a viable option for more wheat acres. If fields have a history of sulfonylurea herbicide use within the last year, a tolerant variety needs to be planted.

Low pH Tolerance/Acid Soil Tolerance

A select few commercial varieties appear to have better tolerance to acidic soil conditions than others; however, not enough data has been collected to generate ratings on low pH tolerance. Refer to individual companies for these ratings. Remember that correcting soil pH with lime is the best solution for growing canola in acidic soils. Planting a low-pH-tolerant variety helps recover some of the lost yield potential, but it is not a long-term, viable solution to correcting the overall problem.

Other Important Traits

Other important traits to consider include relative maturity, heat tolerance at flowering, blackleg resistance, and pod shattering resistance. Seed treatments that include a fungicide and an insecticide should be used to protect against soilborne diseases and fall insect pressure, respectively. Improved varieties and hybrids are continuously being developed.

Seeding

Small-grain and row-crop seeding equipment can be used to plant canola. A well-prepared seedbed is more critical for canola stand establishment than for cereal grains because of canola's small seed size. Factors such as lack of surface soil moisture, soil compaction, crusting, crop residue, and waterlogging reduce canola establishment. Lessening the impacts of these conditions beforehand is critical to establishing a successful canola crop.

Seedbed Preparation

Conditions promoting rapid germination and early, uniform establishment are important for enhancing weed control, winter hardiness, and yield. A level, firm seedbed, which is moist throughout its depth, is advantageous. The soil surface should have decent granular structure, with 30 to 45 percent fine material, and only enough large clumps to prevent soil erosion. A moderate amount of crop residue on the soil surface to reduce soil erosion is desirable.

If the seedbed is too fine or overworked, it loses soil moisture and easily develops a crust. Planting into an overworked seedbed results in the seed being planted too deeply, because the seed furrows will fall into the seed row, covering the seed with excessive amounts of soil. Seedbeds that are too coarse can result in poor seed placement, poor seed-to-soil contact, and soil moisture loss.

To conserve moisture, each tillage operation should be shallower than the one before. Preplant fertilizer and herbicide are often applied before the final tillage operation. The final tillage operation should kill the last flush of weeds and bring soil moisture close to the surface. Rollers may be used with or after the last tillage operation to firm the soil and to bring moisture into the planting zone. Packer wheels on drills also improve seed-to-soil contact.

Consider seeding into a stale seedbed to conserve soil moisture. A stale seedbed has received rain since the last tillage operation, and weeds are controlled by a preplant herbicide application rather than by tillage. In general, this means having all tillage work complete and the field ready to plant by August 1 in Kansas and September 1 in Oklahoma and Texas.

Seeding Date

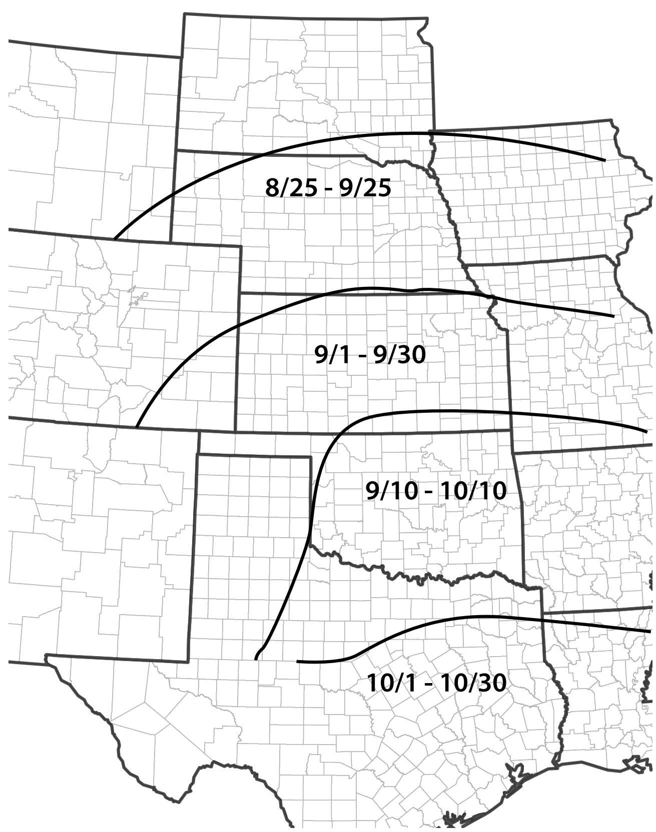
Seeding date is critical to establishing a crop with sufficient growth for good winter survival. Generally, winter canola is planted 6 weeks before the first killing frost (lower than 25 degrees Fahrenheit) for an area. The range of planting dates across the region is illustrated in Figure 3. Seeding dates also may be defined by the availability of crop insurance in an area. The majority of Kansas counties have a September 1 to September 30 planting window. In Barber, Harper, and Sumner counties, it is September 10 to October 10. For Oklahoma, the planting window is September 10 to October 10. In Texas, it ranges from September 1 to September 15 in the northern Panhandle to October 1 through October 30 across central regions of the state. Spring types are planted in Texas at similar times to oat planting (March into April) and are sometimes planted in the fall.

Better winter survival often is observed when planting earlier in the planting window rather than later; however, sometimes planting too early results in large plants using excessive water and nutrients. Large plants may exhibit an elevated crown (rosette), especially if planting populations are high. Plants may be at greater risk of winterkill because the crown is elevated to an unprotected position above the soil surface. Planting too late may result in smaller plants that have insufficient carbohydrate reserves and inadequate size to maximize winter survival. Thus, winter survival often decreases with earlier- or later-than-optimum planting. Seeding date also influences canopy cover, weed suppression, and yield potential.

Seed Size and Seeding Rate

Open-pollinated canola seed of average size has approximately 100,000 to 150,000 seeds per pound, while hybrid canola seed ranges from 60,000 to 100,000 seeds per pound. Photo 4 illustrates this difference. Seed tags display the seed count per pound to help determine the

Figure 3. *Winter canola planting dates for the southern Great Plains.*



appropriate seeding rate. The percent of seed that emerges varies with seed quality, seed germination percentage, soil conditions, planting depth, crop residue, and seeding method.

Average seeding rates in the southern Great Plains for open-pollinated varieties with good seedbed preparation at the optimum planting date are 3 to 5 pounds per acre, or about 300,000 to 500,000 live seeds per acre, depending on germination and seed size. In research conducted by Kansas State University, similar yields have been obtained for seeding rates of 300,000 to 450,000 seeds per acre in narrow rows. Yields tended to decline below 225,000 seeds per acre for open-pollinated varieties in narrow rows.

Since hybrid seed is larger, more costly, and the plants tend to be more vigorous, planting rates are based on pure live seeds per acre. As a general rule, seeding rates for hybrids are approximately 250,000 pure live seeds per acre in narrow and wide row widths. Kansas State University research has shown that hybrids can produce respectable yields at 175,000 seeds per acre in 30-inch rows. Typically, hybrids respond better than open-pollinated varieties at seeding rates below 250,000 seeds per acre.

A poorly established crop should be carefully evaluated before destroying it in the early spring. A thin stand can compensate for open space by developing additional branches; however, thin stands may result in uneven maturity at harvest and can increase weed problems because the crop cannot form a complete canopy. A thin stand that is evenly distributed across the field is likely to produce higher yields than a field with large gaps in plant stand.

Thick stands promote early, uniform maturity and thinner stalks, which are easier to harvest; however, thick stands may produce smaller, less vigorous plants prone to winterkill. Populations above 15 plants per square foot do not enhance yield and increase potential for lodging and disease pressures.

A harvest population of four to 12 plants per square foot is optimum. Significant yield differences usually do not occur unless populations at harvest are less than one plant per square foot.

Seeding Depth and Row Spacing

Canola seeds are small, about 2 millimeters in diameter, so careful placement at a shallow depth is advised. In a firm, moist, conventionally tilled seedbed, the best germination and emergence occurs at seeding depths of ½ to 1 inch. Canola can emerge from greater depths, but seeding deeper than 1 inch may delay emergence, reduce seedling vigor, and delay crop development.

Canola has difficulty forcing its way through thick soil covers or crusted soil. If the seedbed dries too fast, emergence from shallow depths may not be uniform. A firm seedbed does not mean pressing the seed furrow hard with packing wheels. Drill-type press wheels should have just enough pressure to lightly firm the seed and close the furrow. As a general rule, cover the seed with ½ inch of moist soil, with a minimum amount of dry soil on top of that. A firm seedbed is essential for good seeding depth control, which is why some producers prefer the stale seedbed approach.

Table 4. *Plant population densities affected by drilling speed.*

Drilling Speed (mph)	Plants per ft^2	Percent of 5 mph
4	9	109
4.5	8.5	107
5	8	100
5.5	6	77
6	5.5	67
7	5	63

Placing the seed at a uniform depth is the first step in achieving a uniform stand. Seeding depth is greatly influenced by planting speed. The optimum planting speed is about 5 miles per hour. Increasing planting speed from 5 to 7 miles per hour reduces canola stands by about 37 percent (Table 4). This is due to vertical oscillation of the openers, resulting in seed placement at various depths. Slowing planting speed prevents excessive vertical oscillation and improves seed placement. If planting speed must be increased to seed a large number of acres, increasing the seeding rate may compensate for the reduced stands.

The 6- to 15-inch row widths available on commercial grain drills are commonly used for canola. Row widths in this range typically show no differences in yield. Narrower spacing provides quicker canopy closure, reduces broadleaf weed competition, and lessens wind shattering before harvest. Because in narrow-row widths, plants are more spread out and are not competing against one another, better winter survival is often observed. Wider row spacing is sometimes used when grain drills cannot be accurately calibrated to seed the appropriate seeding rate. Some producers prefer to use wider row spacing to allow better coverage of herbicides on winter annual weeds.

Canola production in 30-inch rows is gaining some interest, especially among growers who want to seed no-till and preserve the previous crop's residue. Row-crop planters with precision plates can be used to plant winter canola. Some advantages to using row-crop planters are accurate seed metering, better depth control, residue removal from the seed row, and reduced seeding rates. Research studies have shown 30-inch spacing may reduce yield by 5 to 15 percent, while other studies have shown no significant difference between narrow and 30-inch row widths. At wider row widths, reduce the seeding rate, as too many plants per foot of row can reduce yield potential because of inner-row competition and poor winter survival. Some winterkill is usually observed in 30-inch row widths because of self thinning.

Plants per foot of row can be used to evaluate canola stands (Table 5). Plants per square foot can be used when

Table 5. *Expected harvest plant population (plants per foot of row) seeded at 5 pounds per acre.*

Seeds per Pound	Row Spacing (in.) 7	8	10	14	16	20	30
60,000	2.6	3.0	3.7	5.2	6.0	7.5	11.2
70,000	3.0	3.5	4.4	6.1	7.0	8.7	13.1
80,000	3.5	4.0	5.0	7.0	8.0	9.9	14.9
90,000	3.9	4.5	5.6	7.8	9.0	11.2	16.8
100,000	4.4	5.0	6.2	8.7	9.9	12.4	18.7
110,000	4.8	5.5	6.8	9.6	10.9	13.7	20.5
120,000	5.2	6.0	7.5	10.4	11.9	14.9	22.4
130,000	5.7	6.5	8.1	11.3	12.9	16.2	24.2

Expected harvest plant population (plants per foot of row) seeded at 5 pounds per acre.

- Optimum
- Near Optimum
- Less Desirable
- Least Desirable

the canola is seeded at narrow row spacing, but at wider row spacing, less-than-desirable numbers may result. Table 5 illustrates expected plant populations in plants per foot of row at various row spacing and seed sizes when seeded at 5 pounds per acre. As a rule of thumb, 65 to 85 percent of the seeds planted develop into viable plants. The numbers were calculated assuming that 65 percent of the seeds planted emerge and the plants survive the winter. The target population is five to 10 plants per foot of row, regardless of row spacing.

Calibration Procedure for an End Wheel Grain Drill (Volumetric Method)

Calibrating a grain drill or planter is one of the most important steps to ensure successful stand establishment. Taking the time to calibrate reduces the threat of over-seeding and saves producers money. Remember that not all grain drills are manufactured the same, so calibrate each box or section as if it is a separate drill. Seed sizes vary among varieties, so it is important to recalibrate the drill when changing varieties. The calibration process needs to be repeated at least three times to ensure the drill meters out the appropriate amount of seed. To calibrate a grain drill, follow the procedures below.

Obtain the following materials:

- Two syringes without needles: one 10- to 15-cc and one 50-cc (1 cc = 1 mL)
- Four to six 1-quart plastic bags
- Six to eight rubber bands
- Jack, and
- Measuring tape

Preparation:

- Properly clean the drill by removing all other grain and debris from the box. Inspect seed tubes for holes and clogs before seeding.
- Remove seed tubes and collect calibration samples from the drill spouts rather than the tubes.
- Calculate the desired seeding rate based on variety type, seed size, and germination percentage.
- Set the drill to the canola or rapeseed setting in the operator's manual. This may be close to zero. A speed reduction kit or plugging every other row may be required for older machinery.
- It is easier to calibrate a grain drill by lifting the drive wheel off the ground. This allows rotating by hand rather than pulling the drill back and forth.
- Measure out 100 feet if the drive wheel cannot be lifted.
- Make sure the gears on the drill are engaged.
- Using the following equation, calculate the number of drive wheel revolutions to travel 100 feet.

  (Height of tire in inches × 3.14) ÷ 12 inches per foot = feet per revolution

  100 feet ÷ feet per revolution = number of wheel revolutions to travel 100 feet

  Example:

  (30 inches × 3.14) ÷ 12 in. per foot = 7.85 feet per revolution

  100 ft ÷ 7.85 feet per revolution = 12.75 revolutions to travel 100 feet

Calibration:

- Put enough seed into the box to ensure accuracy and "prime" the drill by either turning the drive wheel by hand or by pulling it forward, depending on the chosen method.
- Place a mark on the drive wheel to use as a reference when counting wheel revolutions.
- Attach bags over seed tubes with rubber bands. Try to collect from at least four tubes from each drill section.
- Turn the drive wheel the predetermined number of revolutions for 100 feet, or pull the drill forward 100 feet.
- Measure the amount of seed collected from each bag by dumping the seed into a syringe.
- Use Table 6 to determine how much canola should be in each bag based on row spacing and how many rows were collected into one bag.

Table 6. *Total seed volume (cc or mL) collected in 100 feet.*

Row Spacing (in.)	One Row	Two Rows	Four Rows
6	3.6	7.2	14.4
7	4.2	8.4	16.8
7.5	4.6	9.3	18.6
8	5	10	20
10	6.2	12.4	24.8
14	9	18	36

Make sure all rows are feeding undamaged seed. If any rows are not seeding or grinding seed, then plug every other row. Recalibrate the drill, catching twice as much seed in each row. Many producers are seeding on 15-inch rows because of trouble with calibrating small seed in an older drill. Plugging every other row from the start makes drill calibration easier and helps improve stands.

Broadcast Seeding

In years of excessive rainfall, canola producers may attempt broadcast seeding if it is the best option for getting the canola planted on time. Broadcast seeding is faster than seeding with a drill, especially if the field has many low-lying areas that are prone to standing water. Broadcast seeding could provide better seed placement if the only alternative is "mudding-in" seed. Under wet field conditions, canola stands are often negatively affected by mud caking on the openers, plugging the seed tubes, or wrapping around the packing wheels.

Important tips for broadcast seeding:

- Broadcast canola on warm, moist soil to increase the chance of meeting desired yield potential.
- If blending seed with fertilizer, seed immediately after blending. Fertilizer, especially nitrogen fertilizers, can reduce canola seed germination rates within the first day after blending.
- Increase the seeding rate. A higher seeding rate can compensate for poorer seed germination from broadcast seeding and it may provide a greater margin of error if the seed-to-fertilizer ratio does not stay consistent as the floater tank empties. A floater with two tanks, one for seed and one for fertilizer, may reduce or eliminate this risk.
- If conditions improve, a shallow cultivation or harrowing improves seed-to-soil contact. Check the seed placement as if using a drill to ensure adequate incorporation to allow uniform emergence.
- Heavy residue increases the risk of failure. Broadcast seeding onto fields with heavy residue inhibits seed-to-soil contact for optimum establishment; however, cultivating these fields ahead of broadcasting may not improve the seedbed because wet soils can become cloddy and crusted.
- Be careful with herbicide application timing. Seed on the soil surface may be highly vulnerable to certain herbicide applications. To be safe, apply all burn-down herbicides before seeding.
- Canola that is broadcast seeded is insurable; however, it must be mechanically incorporated and inspected by the insurance provider.

No-till Canola Production

Producers can grow canola in no-till, but careful attention must be paid to the previous crop residue. No-till seeding canola into heavy residue, particularly wheat residue, often results in stand losses over the winter. The decrease in stand may be due to several factors related to soil properties, microclimate differences at the soil surface, and crown height of the canola plants.

Stand establishment can be successful if using no-till equipment that is set correctly. In general, the rate of emergence and total percent emergence (based on 5 pounds per acre seeding rates) has been similar between no-till and conventional seeding. In some cases, a higher rate of emergence has been observed in no-till because the soil moisture content was higher near the soil surface. Higher soil moisture is a characteristic of no-till systems. In other cases with large amounts of residue, seed-to-soil contact has been inadequate and stand establishment can be poor.

In no-till, it is best to place the seed approximately ¾ to 1½ inches deep to ensure proper seed-to-soil contact. Getting good seed-to-soil contact is important, especially in heavier residue. Placing the seed too shallow and not penetrating the soil surface results in shallow-rooted canola plants. Often, the roots may not penetrate the soil surface and simply develop underneath the residue.

Achieving uniform stand establishment is more easily done when the previous crop residue has been evenly distributed at harvest. Burning can be a useful management tool if residue is not evenly distributed or is too thick. If this option is selected, burn immediately before seeding to help conserve soil moisture and minimize the risk of erosion. Most no-till seeders and planters work best in the heat of the day when the coulters, disk openers, or hoe openers cut through residue more effectively. Residue is much tougher when conditions are damp and humid, which hinders proper seed placement or simply pushes the residue into the seed row.

Soil temperatures in no-till fields will be lower during planting compared to conventionally tilled fields with no residue on the surface. Wheat residue buffers soil temperature fluctuations at the ½ to 1½-inch depths. Lower soil temperatures under heavy residue may reduce crop growth. For this reason, seeding in the early part of the planting window is recommended. If possible, removing residue from the seed row increases soil temperatures. Using an aggressive coulter, row cleaner, strip tillage, or hoe opener may move enough residue to increase soil temperature in the seed row. Furthermore, moving residue away from the seed row allows for more radiant heating of the near-surface air temperature during overnight hours, which may play a role in reducing leaf tissue damage during freeze events.

Differences in yield between no-till and conventionally tilled fields may be influenced by soil bulk density. Bulk density is the mass of soil divided by the total volume it occupies; thus, a compacted soil has a high bulk density. To determine the effect of soil bulk density on winter canola root growth, a greenhouse study was conducted by Oklahoma State University. Canola root biomass decreased linearly with increasing bulk density for both sandy and clay soils. This means that higher bulk densities could reduce winter canola root mass, which may reduce winter survival. As a result, careful attention should be placed on the physical properties of the soils in no-till fields when seeding winter canola, especially in fields that have been in no-till less than 3 years. Be aware of the negative effects on plant growth associated with seeding into a no-till field with a high bulk density. On average, it takes more than 3 years for good soil structure to develop in no-till fields.

Competitive yields may be achieved under no-till conditions. Experience shows moving residue from the seed row — whether by a light tillage pass, coulter, row cleaner, baling or burning — is the best way to increase winter survival and yield potential in no-till production.

Tips for Successful No-till Seeding

- Pay attention to seeding depth. The seed should be placed from ¾ to 1½ inches deep. If the seedbed is uneven, place the seed at one inch to improve seed-to-soil contact. Do not place the seed in residue.
- Consider using a row crop planter on 15- or 30-inch row spacing to seed canola in no-till.
- Do not plant the field if the previous crop residue is not evenly distributed. Perform a light tillage operation, bale, or burn the residue.
- Plant a winter canola variety or hybrid that has excellent winter hardiness and low crown development.
- Burning residue immediately before seeding increases winter survival, but may not be an option for producers who value residue.
- Consider increasing the seeding rate by 15 to 20 percent. This is often recommended for crops like wheat when a heavy amount of residue is present.
- Planting speed should not exceed 5 miles per hour for no-till canola.
- Remove as much residue from the seed row as possible. A wavy coulter may increase soil disturbance and remove residue from the seed row.
- Have sufficient down force on row units so they function correctly.
- Pay careful attention to residue toughness; planting in the heat of the day improves these conditions. Make sure coulters and openers are cutting the residue and not hair-pinning it.
- Check seeding rate and depths often, as conditions can change across and between fields.
- Plant early in the planting window.
- Consider seeding behind a crop such as soybeans that has less residue than wheat, or seed after a previous sorghum crop that has had a fallow period.
- Avoid seeding canola into fields recently converted to no-till. No-till fields established more than 3 years have better soil structure and lower bulk densities.
- Consider using a strip-till unit to move residue from the seed row for planting.

Canola Growth and Development

The growth and development of winter canola is divided into easily recognizable growth stages (Figure 4). The length of each growth stage is influenced by temperature, moisture, light, nutrition, and variety. Producers with an understanding of how a canola plant develops and how it is affected by production practices can make more effective management decisions.

Emergence

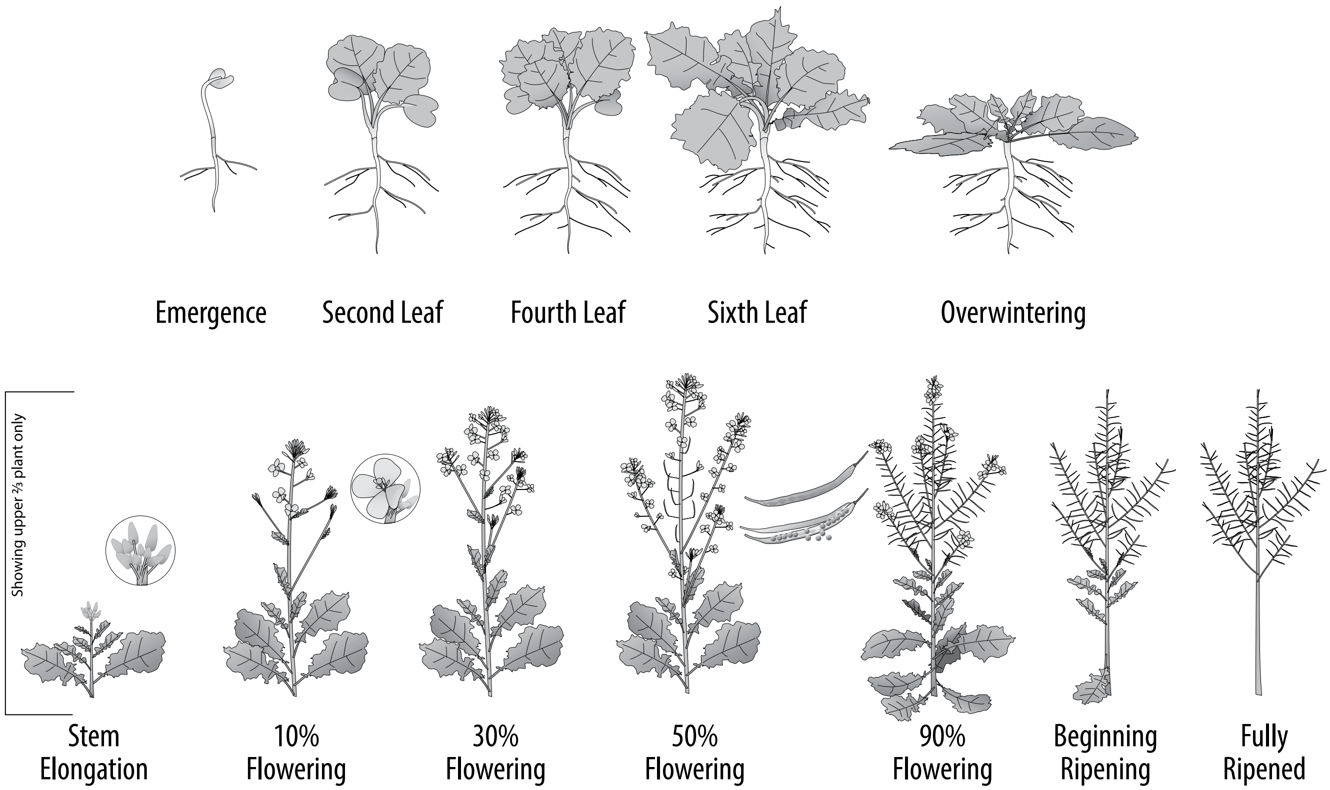
The seed absorbs water and swells, splitting the seed coat. The root grows downward, developing root hairs and anchoring the developing seedling. The hypocotyl (stem) grows upward, pulling the cotyledons or seed leaves, covered by the seed coat, through the soil. Seedlings typically emerge 4 to 10 days after planting and develop a short stem (Photo 5).

Seedling

The cotyledons at the top of the hypocotyl expand, turn green, and provide nourishment to the plant. The roots also continue to develop. Unlike wheat, whose growing point is protected beneath the soil surface during early development, the growing point of canola is above the soil between the two cotyledons. Thus, canola seedlings may be more susceptible than cereals to environmental hazards, grazing, disease, and insect damage at this stage.

A seedling develops its first true leaves 4 to 8 days after emergence (Photo 6). The rate of leaf expansion is 7 to 10

Figure 4. *Canola growth and development stages.*



days per leaf. Leaf stages can be identified by counting the number of fully opened leaves.

Rosette

The plant establishes a rosette with larger, older leaves at the base and smaller, newer leaves at the center (Photo 7). The total number of leaves a plant produces depends on factors such as genotype, planting date, seeding rate, nutrition, temperature, and soil moisture. Canola may produce 10 to 15 leaves in the rosette stage.

The root system continues to develop, with secondary roots growing from the taproot. The stem length remains unchanged but its thickness increases. Winter canola over-winters in the rosette stage. Spring types form considerably smaller rosettes than winter types because they do not overwinter.

Rapid establishment of a leaf canopy is important in the development of a canola crop. A crop that establishes on time has a greater ability to capture sunlight, produce nutri-ents for growth, and develop a viable crown and root system. This fall growth sustains the plants throughout winter dormancy. A complete crop canopy has a greater ability to out-compete weeds, reduce soil water evaporation, reduce soil erosion, and increase dry matter production.

Overwintering

Winter survival is strongly affected by fall growth, the genetics of the variety, the environment, and management. To improve winter survival, plants should have a large crown and an extensive root system to store carbohydrates used during the colder months when growth is slow. Survival is increased when the plants have greater than six true leaves and the canopy height is approximately 6 to 12 inches above ground. Root diameter at the base of the rosette should be ¼ to ½ inch.

Plants smaller than three true leaves have a greater risk of winterkill. Plants with canopies larger than 20 inches tall require more soil moisture and may succumb to mois-ture stress. Too much fall growth may result in early stem elongation and crown injury from freezing temperatures, causing the plant to die. Additional stress factors such as excessive insect feeding and heaving from the soil also may reduce survival.

During the winter, many visible, physical changes take place. Growth slows as a result of decreasing temperature and shorter day length. Winter hardening begins after several days of near-freezing temperatures. This occurs when cold temperatures set off a chain of plant gene activity to produce or degrade proteins that protect cells. Plants may still be growing, but they produce smaller cells and eventually dehydrate. Thus, plants have cells with a higher concentration of soluble substances that are more resistant to frost damage.

Older leaves often discolor to white or brown and die. Photos 8 and 9 illustrate the typical winter appearance of semi-dormant canola. In colder years, much of the leaf tissue dries and turns brown, but as long as the crown does not turn brown and die, the plants will resume rapid growth in the early spring. The amount of leaf loss depends on the variety grown, the amount of fall growth, the amount and length of snow cover, and variability in winter temperatures. In mild winters, leaf loss tends to be less than in cold winters.

Depending on the field and variety, all or some parts of the field may turn a shade of purple or red as cold temperatures arrive. Some degree of purpling is normal as plants enter winter dormancy; however, severe purpling is an indicator that plant stress is occurring. The purpling is the production of anthocyanin in the leaf tissue.

There can be many causes for plant purpling, including fertility, insect damage, soil type, waterlogged soils, dry soils, colder temperatures, and other environmental stresses. Nitrogen fertility appears to be one of the leading causes of plant purpling, because fields that have higher rates of fall nitrogen fertility often show less purpling. This has been observed in several producers' fields and in research trials where nitrogen-rich strips were used as a reference point. Canola usually outgrows the purpling, and color may improve with topdressing. Some varieties show more plant purpling than others. Use soil tests and tissue samples if plant purpling is cause for concern.

Bolting and Budding

Growth resumes in late winter or early spring as temperatures increase and day length becomes longer. In the spring, new leaves appear from the growing point. Regrowth generally begins when average temperatures are greater than 40 degrees Fahrenheit. Winter canola must be vernalized to initiate flowering. A cluster of flower buds becomes visible at the center of the rosette and rises as the stem rapidly bolts (Photo 10) or lengthens. Leaves attached to the main stem unfold, and the cluster of flower buds enlarges as the main stem elongates. Secondary branches develop from buds in the axils of some leaves. Spring types have a lower vernalization requirement and essentially begin bolting and budding as the canopy develops.

The main stem reaches 30 to 60 percent of its maximum length before flowering. Maximum leaf area is achieved at the start of flowering and begins to decline with the loss of bottom leaves. Upper leaves are the major sites of photosynthesis and provide the necessary nutrients for the growth of stems and buds. Rapid development and growth of a large leaf area strongly influences pod set, early seed development, and potential yield.

Flowering

Flowering begins with the opening of the lowest buds on the main stem, or raceme, and continues upward, with three or more flowers opening each day (Photo 11). Secondary branches begin flowering 2 to 3 days later.

Under normal growing conditions, flowering of the main stem continues for 2 to 4 weeks (Photo 12), and full plant height is reached by peak flowering (50 percent of flowers are open). Branches continue to grow longer as buds open and pods develop. The first buds to open become the pods lowest on the raceme. Above them are the open flowers and the unopened buds.

Canola plants initiate more buds than can develop into productive pods. This is a natural process. The amount of loss depends on leaf, stem, and pod health, and the environmental stresses encountered during flowering and pod set. The plant only maintains the number of flowers and pods it can support through photosynthesis under existing conditions. Canola does not translocate nutrients from other parts of the plant to the developing seeds to the same degree that some crops do. Thus, approximately 60 percent of the open flowers are developed into productive pods and maintained by the plant until harvest. Canola does exhibit an indeterminate flowering period that allows it to compensate for yield-limiting factors.

Maturation and Ripening

Maturation begins as the last flowers fade from the main raceme (Photo 13). Competition for resources between opening flowers and pods eventually interrupts flowering. Older pods at the base of the main raceme are more developed; however, the tops of the raceme may dry out quickly if hot, dry winds occur during this time. At this stage, the stem and pod walls are the major sources of nutrients for seed growth. Leaves, stems, and pod surfaces should be kept free from disease and insect damage. Stresses to the nutrient-production capacity of these plant surfaces lead to reductions in seed yield and oil content.

The pod is divided into two halves by a membrane that runs its full length. Approximately 15 days after a flower bud opens, seed expansion begins. The young seed is somewhat translucent as the embryo develops rapidly. Pod weight increases and reaches maximum fresh weight approximately 35 to 45 days after flowering. Seed development is complete at 35 percent moisture content at this time. Oil synthesis begins approximately 35 days after flowering and is complete by about 40 percent seed color change. Seeds reach maximum dry weight approximately 70 days after a flower opens.

A ripening stage, characterized by plant and seed color changes, follows seed filling. The pods turn yellow, then brown, and progressively become brittle as they dry (Photo 14). The seed coat turns from green to brown, and seed moisture is lost rapidly at approximately 2 to 3 percent per day. As the seed coat changes color, so does the seed. The embryo, which fills the entire seed, begins to lose its green color and when the seed is completely ripe, is a uniform bright yellow.

When all seeds in all pods have matured, the plant dies; however, canola is typically harvested while the lower stem is still green. Mature pods are split easily along the center membrane, and some seed can be lost by shattering. Average seed moisture of 8 to 10 percent with no green seed visible is the ideal moisture content for harvest.

Factors That May Limit Pod Set

Canola flowering and pod set are critical periods in plant development because abiotic and biotic stresses may limit pod development or cause pod abortion, negatively affecting grain yield and oil content. Every year, canola producers observe crops with blanks or missing pods on the main and axillary stems caused by stresses that inhibit fertilization of flowers. It is important to accurately determine the cause of the stress in order to take steps to reduce the effects on future crops. Canola is more management intensive than winter and spring cereals; therefore, field scouting is critical to identify production problems, especially insect pests and diseases, before they reach economic thresholds.

Canola produces 70 to 80 percent of its seed through self-pollination, which means that wind or insects are not necessary for proper seed set. Generally, fertilization of the pistil (female portion) occurs within 24 hours of the release of pollen. Some of the factors that limit pod set are explained in the following paragraphs.

Heat stress

Heat stress is a problem when high temperatures occur during flowering and early pod set, and it is more severe when plants are growing under drought conditions (Photo 15). A canola plant is most sensitive to heat stress during flowering; however, oil content may be reduced when heat stress occurs during seed formation.

Sunscald has appeared in many fields across the southern Great Plains and is often mistaken for nutrient deficiencies (Photo 16). Sunscald occurs during periods of heat stress at ripening. The main symptom is purpling on the stems and pods, which is an abiotic stress response. The purpling is due to higher levels of the anthocyanin pigment and a lack of chlorophyll in the naturally senescing tissue. Some varieties show more sunscald than others. Confirm the observance of sunscald by checking the underside of the pods or branches (areas not exposed to the sun) for normal color. Sunscald is not usually yield-limiting.

Cold stress

The extent of damage from cold stress depends on the growth stage and how low and long temperatures dropped. Longer durations of temperatures in the mid-20s increase the severity of damage at the flowering and pod set stages.

Cosmetic injury will be observed immediately, but canola should begin to recover as soon as temperatures warm up. At the flowering stage, we often see bleaching of leaves and a bend or crook in the stem and flowering racemes. Often, these bends may take the flowering racemes to the ground; however, plants may straighten and continue flowering normally. If seed set is below the main canopy of pods, problems at harvest may occur.

Unopened buds at the time of the cold stress should produce flowers and growing pods should produce viable seed. The open flowers will be lost and permanent bends in racemes will be observed. In severe cases, the main raceme and some secondary branches completely freeze off and die. If conditions improve and the plant continues to flower, these damaged plant parts will turn brown. The crop can compensate for the losses with secondary branching.

Stem splitting and cracking are often observed. Canola will continue to grow even if the stem is split wide open; however, these splits cause concern for lodging as the crop produces pods and seeds. Cracks are usually cosmetic, but do provide an entry point for fungi that could cause the stem to rot. Other effects on the plant include delayed maturity and reduced plant height.

Moisture stress

Waterlogged soils can cause pod abortion. Excessive water reduces pod formation through nutrient leaching, anaerobic conditions affecting nutrient uptake, and premature senescence. Canola roots require a mixture of air and water in the soil to function properly. Soils that are waterlogged for 3 or more days at flowering negatively affect the number of pods per branch and number of seeds per pod. The conditions will be worse in combination with high temperatures.

Dry soil conditions can limit pod set, but if moisture is received before ripening, then the plant may compensate by setting new buds, flowers, and pods on secondary branches. This may increase the overall yield, but it also could delay harvest. Under severe drought, the crop may continue to grow after initial ripening if conditions improve. If the primary pod set is ripe, then the new growth will delay harvest and may lead to shattering losses. In most cases, it is best to harvest the pods that ripened first to attain maximum yield. Usually, the canola plant dies after harvest, but the stubble may continue to grow or remain green if the crop was severely stressed before harvest and normal conditions return.

Research conducted in Colorado indicates lower numbers of pods and seeds with water stress during reproductive development and lower seed weight with stress during grain filling. Most canola water use comes from the top 47 inches of soil depth. Water can be removed from a depth of 65 inches. The following yield formula was generated to explain canola water use:

Yield (lbs per acre) = 175.2 lbs per acre per in. × [water use (in.) – 6.0]

Heavy rain

Heavy rains are common across the southern Great Plains during the flowering stage of winter canola. Heavy rain and over-irrigation can knock flowers from stems and reduce pollination. Plants often recover from this damage with later-forming branches.

Insects

Insects can reduce pod set at the early bud stage when feeding for pollen. Insects also can reduce yields at flowering and pod set, especially under stressed conditions. Sweep net sampling and crop scouting from bolting to maturation are encouraged. Common insects that feed on buds, flowers, and pods include cabbage aphid (*Brevicoryne brassicae*), cabbage seedpod weevil (*Ceutorhynchus assimilis*), diamondback moth (*Plutella xylostella*), lygus bug (*Lygus* spp.), variegated cutworm (*Peridroma saucia*), harlequin bugs (*Murgantia histrionica*), and false chinch bug (*Nysius raphanus*). See the *Insect Pests* section beginning on page 24 for descriptions.

Diseases

Diseases that form on the leaves, stems, and pods inhibit the nutrient-producing capacities of these plant parts and may lead to a reduction in pod set. Three of the more common diseases are Alternaria black spot (caused by various species of *Alternaria*), powdery mildew fungus (*Erysiphe cruciferarum*), and blackleg (*Leptosphaeria maculans*). Fungal diseases are worse in wet years. See the *Diseases* section beginning on page 21 for descriptions.

Herbicides

Herbicide applications at the early bud stage have caused a reduction in pod set. Although canola is tolerant to many herbicides, at least part of the tolerance results from metabolizing the herbicide. This may cause some stress in the plant at flowering when yield potential is being determined. Under optimum conditions, the plants may compensate by producing more flowers. When combined with drought or nutrient stresses, the plants may not compensate and yield loss will occur. Always read and follow herbicide label directions for appropriate application timing.

Fertility

Nitrogen, sulfur, and boron deficiencies can cause poor fertilization and pod set. Symptoms such as poor branching, reduced plant height, poor pod set, and noticeable differences in plant color are common with nitrogen and sulfur deficiencies. Severe sulfur deficiency can cause sterilization of the canola flowers. In drought years, nutrient stresses occur if the roots cannot extract sulfate-sulfur from the soil profile, even at adequate sulfate-sulfur fertility levels. Once moisture is available and the roots can acquire adequate sulfur, flowering and pod set often return to normal.

Fertility Management

Southern Great Plains

Soil fertility and fertilizer management play a major role in the winter survival, yield, and oil quality of canola. Soil testing to determine the nutrients currently available in the soil is the first step in developing an effective canola fertilization program. Both surface and subsurface soil samples should be collected following sampling guidelines from the cooperative extension service in your state. In most cases, surface samples should be collected to a sampling depth of 6 inches, or in the plow layer, and analyzed for pH and lime requirement, phosphorus, and potassium. In some cases, soil organic matter, plant-available nitrogen, sulfate-sulfur, and micronutrient tests, such as boron and zinc, may improve the overall fertilizer recommendation package. Kansas State University Department of Agronomy, Oklahoma State University Department of Plant and Soil Sciences, and Texas A&M University Department of Soil and Crop Sciences have downloadable fertilizer recommendation programs available at their soil testing lab websites: *www.agronomy.ksu.edu/soiltesting*, *www.soiltesting.okstate.edu*, and *soiltesting.tamu.edu*, respectively. Underestimating the soil fertility needs of winter canola will result in reduced winter survival, poor plant development, reduced pod set, lower seed quality, and poor yields (Photos 17 – 18). The Oklahoma State University Factsheet PSS-2171, *Diagnosing Nutrient Deficiencies in Canola*, describes common nutrient deficiency symptomology in canola and provides a flow diagram for diagnosis.

Subsoil samples for mobile nutrients such as nitrate-nitrogen, sulfate-sulfur, and boron should be taken to a depth of 0 to 18 or 0 to 24 inches, depending on the state's recommendations being followed. Some people prefer to use a two-sample system, using the 0 to 6 inch sample collected for pH, phosphorus and potassium and a second 6- to 18-inch or 6- to 24-inch sample for nitrate and sulfate only. Regardless of how it is sampled, it is important to use a profile sample from the surface to 18 or 24 inches deep to get a complete picture of available nitrogen and sulfur in the soil.

Fertilizer recommendations for canola are similar to those for winter wheat, with two exceptions. Canola uses slightly more nitrogen and sulfur than comparable yields of wheat. High nitrogen applications in the fall should be avoided, as they can lead to excessive fall growth and reduced winter survival. Phosphorus, potassium, sulfur, and other soil amendments can be applied before planting.

Lime recommendations

Canola is less tolerant to soil acidity than winter wheat. Therefore, pay particular attention to low pH soils before planting canola. Best growth has been shown to occur at a soil pH of 6.0 to 7.0, with lime recommended when the soil pH is below pH 5.8. Normally, the goal of liming for canola is to reach a target pH of 6.0 to 6.5. The Shoemaker, McLean, and Pratt (SMP) and the Sikora Buffer are used to estimate lime requirement across the region. The specific lime recommendations for Kansas and Oklahoma using the buffer pH are given in Table 7. These recommendations are based on a 6-inch sample depth and assume incorporation with tillage. In no-till production systems, the lime reacts only with the surface 2 to 3 inches of soil the first season, and application rates should be reduced by 50 percent. As with wheat, variety selection and liming are important for lower pH sites.

Phosphorus and potassium

Phosphorus and potassium should be applied in the fall, before planting, with the application rate based on current soil test levels. Due to the potential for salt and/or free ammonia injury to seedlings, caution should be taken when applying fertilizer phosphorus and potassium in the row. Safe rates will be discussed later in the section. If soil test recommendations for phosphorus and potassium are high, the majority of the fertilizer should be broadcast before planting. Like soybeans and other oilseeds, canola takes up and removes large amounts of phosphorus and potassium. Crop removal in the grain is approximately 0.9 pound P_2O_5 and 0.45 pound K_2O per bushel.

General phosphorous fertilizer recommendations for use with canola in Kansas and Oklahoma are given in Table 8. Phosphorous deficiency symptoms include leaf bronzing, purpling and chlorosis along with flower and pod abortion (Photos 19 – 20). General potassium recommendations are given in Table 9. These tables give general recommendations over a range of soil test values. Many soils in the region naturally contain high levels of potassium; however, deficiencies of potassium have become much more common in recent years as cropping systems have intensified. Deficiency symptoms include reduced growth, wilting, yellow to yellow-brown coloration at leaf edges, and development of white dead spots and blotches that gradually join (Photos 21 – 22). To maximize production, take a soil test and solve all deficiencies before planting.

Sulfur

Soils having less than 20 pounds per acre sulfate-sulfur (10 ppm SO_4-S) should receive supplemental sulfur. A good rule to follow is to keep sulfur to nitrogen at a ratio of about 1 to 7. Another simple guideline is to apply 20 pounds sulfur per acre, which will be sufficient for low and medium yield levels. The common sources of sulfur available in the region are elemental sulfur, ammonium sulfate, and ammonium thiosulfate. Elemental sulfur or ammonium sulfate can be applied in the fall as a blend with phosphorus, and incorporated into the seedbed or surface applied with nitrogen in the spring. Soil bacteria must oxidize elemental sulfur to sulfate before it is available to

Table 7. *Lime recommendations for canola production. No lime is recommended if soil pH is 5.8 or higher.*

Kansas Lime Recommendations		Oklahoma Lime Recommendations	
SMP Buffer pH	**Target pH = 6.0 lbs ECC/acre[*]**	**Sikora Buffer pH**	**Target pH = 6.5 tons ECCE/acre[****]**
7.2	375[**]	>7.1	0.0
7.0	875	7.1	0.5
6.8	1,500	6.9	1.0
6.6	2,250	6.7	1.4
6.4	3,125	6.6	1.9
6.2	4,125	6.5	2.5
6.0	5,125[***]	6.4	3.1
5.8	6,250	6.3	3.7
5.6	7,625	<6.2	4.2

[*] *ECC = effective calcium carbonate.*

[**] *In no-till systems with no incorporation of lime with tillage, reduce the application rate by 50 percent.*

[***] *At lime recommendations exceeding 5,000 lbs ECC/acre, we suggest applying one-half rate, incorporating, and retesting in 12 to 18 months.*

[****] *ECCE = effective calcium carbonate equivalent.*

Table 8. *General phosphorous recommendations for winter canola based on the Mehlich 3 soil test for the southern Great Plains.*

Kansas Phosphorous Recommendations		Oklahoma Phosphorous Recommendations*	
Soil Test P (ppm)	**Pounds P_2O_5/acre**	**Soil Test P Index**	**Pounds P_2O_5/acre**
0-5	70	0	80
6-10	50	10	60
11-15	30	20	40
16-20	20	40	20
21-30	10	65	0
31+	0		

**Oklahoma soil test phosphorous index is 2 times the ppm value. For example, a soil test phosphorus index of 20 is equivalent to 10 ppm.*

Table 9. *General potassium recommendations based on the Mehlich 3 or ammonium acetate soil tests on the southern Great Plains.*

Kansas Potassium Recommendations		Oklahoma Potassium Recommendations*	
Soil Test K (ppm)	Pounds K_2O/acre	Soil Test K Index	Pounds K_2O/acre
<40	60	0	60
41-60	50	75	50
61-100	30	125	40
101-125	20	200	20
>125	0	250	0

**Oklahoma soil test potassium index is 2 times the ppm value. For example, a soil test potassium index of 200 is equivalent to 100 ppm.*

crops, so sulfur is better applied before planting to ensure availability. Ammonium thiosulfate or ammonium sulfate can be applied in the spring or fall, but thiosulfate should not be topdressed directly on tissue or placed with seed to avoid phytotoxicity. Deficiency results in a severe reduction in pod set and seed quality because canola is a heavy user of sulfur (Photos 23 – 24).

Preplant nitrogen

Managing nitrogen in canola is more demanding than in wheat or grain sorghum, as both over and under application of nitrogen in the fall can lead to problems with winter survival. Profile soil tests should be taken each year before planting to know how much residual nitrate-nitrogen is available for the crop. The total amount of nitrogen needed is directly related to the yield potential of the site. Fertilizer nitrogen needed can be calculated using the following formulas:

Total nitrogen needed (lbs/acre) = 0.05 × Yield Potential (lbs/acre) – profile soil test nitrate-nitrogen (lbs/acre)

or

Total nitrogen needed (lbs/acre) = 2.5 × Yield Potential (bu/acre) – profile soil test nitrate-nitrogen (lbs/acre)

Thus, fertilizer nitrogen needed is the total nitrogen needed for the crop minus the amount of residual soil nitrate-nitrogen present in the soil profile at planting.

Table 10 gives the fertilizer nitrogen needed as a function of yield potential and residual nitrogen in the soil profile. It is important that the soil test be taken before but close to planting in the fall, as samples taken in the spring reflect both the residual soil nitrogen from the previous crop and mineralized soil nitrogen from organic matter and crop residue.

Applying too much of the recommended nitrogen before planting in the fall, or planting in soils with high profile nitrogen levels (>80 pounds per acre), can result in excessive vegetative growth and reduce winter hardiness. It is important, however, to apply some nitrogen in the fall to meet the needs of plant establishment and early growth. Recent research shows that not applying any nitrogen in the fall leads to stressed, stunted, nitrogen-deficient plants, which have a difficult time surviving the winter. Therefore, it is recommended that between one-quarter and one-third of the total season's nitrogen be applied preplant (roughly 15 to 30 pounds per acre including profile nitrate available

Table 10. *Total nitrogen fertilizer needs for canola as affected by yield potential and soil test nitrogen levels on the southern Great Plains.*

Profile N Test (lbs/acre)	Yield Potential (lbs/acre)				
	1,500	2,000	2,500	3,000	3,500
0	75	100	125	150	175
20	55	80	105	130	155
40	35	60	85	110	135
60	15	40	65	90	115
80	0	20	45	70	95
100	0	5	25	50	75

in the fall), with the balance being topdressed in the late winter. If seeding early in the planting window, only apply one-third and if seeding later, apply closer to one-half of the total nitrogen preplant.

Plant health can be severely affected by nitrogen deficiency. Nitrogen deficiency in the fall can lead to a reduction in photosynthetic area and reduce fall plant growth. In the spring, it will lead to yellow, chlorotic, and stunted plants that have reduced yield potential (Photos 25 – 27).

Fertilizer applications with the drill

While research shows banding fertilizer with the seed can greatly benefit canola, like most oilseeds, canola is much more sensitive to ammonia and salt injury than wheat or corn. Therefore, producers should be extremely cautious when band applying fertilizers to avoid seed-to-fertilizer contact. The three most damaging components are nitrogen, potassium, and sulfur. Fertilizers such as urea (46-0-0) and ammonium thiosulfate (12-0-0-26) should not be applied in direct contact with the seed. As a general rule, it is safe to use the ammoniated phosphates such as MAP (11-52-0) and DAP (18-46-0) and potash (0-0-60) as long as the rate of nitrogen to K_2O does not exceed the safe rates in Table 11. If soil recommendations for phosphorus and potassium are high, to avoid the risk of seedling injury and stand reduction, the majority of the fertilizer should be broadcast before planting, unless the drill has separate fertilizer openers (such as 2 inch by 2 inch) to avoid seed-to-fertilizer contact. The Oklahoma State University factsheet PSS-2172, *Starter Fertilizer for*

Winter Canola in Oklahoma, outlines the benefits and risks of applying fertilizer with the seed.

Late-winter or early spring topdressing

Canola responds to nitrogen fertilizer applied in late winter while the plants are still dormant, much like wheat. The balance (two-thirds to three-quarters) of the nitrogen should be applied when ambient temperatures are still low and just as plants begin to show increased growth. Topdress applications should be based on an updated assessment of yield potential, less profile residual nitrogen, and the amount of nitrogen applied in the fall. Either solid or liquid forms of nitrogen can be used before green-up in the early spring. Once the weather warms and growth begins, solid materials are preferred for broadcast applications to prevent/avoid leaf burn. Topdress has also been shown to be a good timing for the application of sulfur. Applying half in the fall and half in the spring is a good recommendation.

It is important to avoid crushing winter canola with applicator tires when it is frozen or after it bolts. Crushed plants will lodge and maturity will be delayed, which can slow harvest and increase the risk of shattering losses. For this reason, applicators with narrow tires and wide booms are preferred.

Nebraska and the High Plains

Fertilizer recommendations for canola are similar to winter wheat and are comparable to guidelines for spring canola from Minnesota and North Dakota; however, yield potential of winter canola is higher than spring canola, so general fertility requirements are higher. Follow soil-sampling guidelines from your state agricultural experiment station, cooperative extension publications, or an accredited soil-testing lab as suggested sampling depths vary somewhat between states. Surface samples should be analyzed for organic matter, pH, phosphorus, potassium, sulfur, and possibly zinc and iron. Deeper samples for residual nitrate should be taken to a 3- or 4-foot depth.

Table 11. *Maximum amount of salt, DAP, and MAP that can be applied in furrow with canola seed.*

Row spacing (inches)	Salt per acre (lbs N + K_2O +1/2 S)	DAP (lbs/acre)	MAP (lbs/acre)
6	13	72	118
7.5	10	56	91
8	9	50	82
12	6	33	54
15	5	28	45
16	4	22	36
24	3	17	27
30	2.5	14	23

Nitrogen

The total amount of nitrogen required depends on the yield potential and amount of residual and mineralizable nitrogen in the soil. Soil organic matter levels through the High Plains typically range from 1 to 3 percent and mineralization usually contributes 20 to 30 pounds nitrogen per percent of organic matter. Assuming canola-rooting depths of 4 to 5 feet in deep soils (similar to winter wheat), measuring residual nitrate becomes important in nitrogen management. Total plant nitrogen requirements can range from 150 to 310 pounds per acre depending on the yield potential of the area or system (non-irrigated versus irrigated). Suggested nitrogen rates for three yield levels and a soil with 2 percent organic matter and varying residual nitrate-nitrogen levels is shown in Table 12.

For soils with 1 percent organic matter, add 15 pounds nitrogen for each yield and nitrate level in Table 12. For soils with 3 percent organic matter subtract 15 pounds nitrogen for each yield and nitrate level.

Phosphorus

Phosphorus should be applied in the fall before or at planting, depending on soil test level. Phosphorus can be broadcast and incorporated or row-applied at planting. Broadcast phosphorus recommendations are given in Table 13 for several currently used soil tests.

Table 12. *Nitrogen recommendations for winter canola in the High Plains.*

Residual Soil Nitrate		Yield Potential (lbs/acre)		
(ppm)	(lbs-N in 3 ft)	1,000	2,500	4,000
2	20	60	120	180
4	45	45	100	160
6	65	30	80	140
8	85	15	60	120
10	110	0	40	100
12	140	0	20	80
14	150	0	0	60
16	170	0	0	40
18	195	0	0	20
20	215	0	0	0

Table 13. *Phosphorous recommendations for the High Plains.*

Soil test method for phosphorus (ppm) level			
Olsen-P	Bray P-1	Mehlich 3	Pounds P_2O_5
0-3	0-5	0-6	80
4-6	6-10	7-12	60
7-9	11-15	13-18	40
10-12	16-20	19-24	20
>12	>20	>24	0

Row-applied phosphorus is a good alternative to broadcasting. For winter wheat, research has shown that one-half the broadcast rate of phosphorus is sufficient for row (seed) application to correct phosphorus deficiency. Because of seed sensitivity to salt, no more than 10 pounds nitrogen + potassium + sulfur should be used with the seed on 12-inch spacing. For narrower row spacing, proportionately higher levels can be used (e.g., 20 pounds nitrogen + potassium + sulfur for a 6-inch row spacing).

Potassium

Since most soils in the High Plains have very high levels of potassium, follow guidelines for wheat if soil tests are lower than 125 parts per million ammonium acetate extractable potassium (Table 14). Canola takes up large amounts of potassium, and potassium fertilizer should be applied before planting.

Table 14. *Potassium recommendations for the High Plains.*

Soil Test K (ppm)	Pounds K_2O recommended per acre
<40	80
41-75	60
75-125	40
>125	0

Sulfur

Soils having less than 10 parts per million sulfate-sulfur should receive supplemental sulfur. A good rule to follow is to apply sulfur to nitrogen at a ratio of 1 to 7. Another simple guideline is to apply 20 pounds sulfur per acre, which will be sufficient for low and medium yield levels. Sulfur can be applied in the fall and incorporated into the seedbed or surface applied with nitrogen in the spring. Sulfur also can be applied in liquid form over the crop.

Weed Management

Rapeseed and Canola on Pesticide Labels

Applicators need to be aware that rapeseed and canola have regulatory meaning in the application of pesticides. The Environmental Protection Agency has crop groupings that segregate crops so that if the "representative commodity" has a tolerance and is registered, other crops in that crop grouping can be included in the application site on a pesticide's label.

Crop Group 20 is Oil Seeds, and rapeseed is the representative commodity. Canola is included within Group 20. Therefore, a pesticide with rapeseed listed as the site of application on the label can be used on canola. For Crop Group 20A, canola is the representative commodity and rapeseed is not listed within this crop group. Therefore, a pesticide with canola listed as the site of application on the label cannot be used on rapeseed. To be certain, it is always best to check with the pesticide company's representative.

Weed Management Techniques

Weed management is a key component of any winter canola production system. In the Great Plains, winter canola can be grown in rotation with many field crops. Weed control benefits linked with crop rotations are achieved by following appropriate weed management practices. Yield losses due to weeds are minimized with successful early season weed control. Once plants are established, winter canola suppresses and out-competes most annual weeds if good management practices are followed. Spring weeds become a problem when canola stands are poor and areas of the field are left open.

For current weed control recommendations see Table 23 on page 37.

At emergence, winter canola has difficulty competing with established weeds. Planting winter canola into a weed-free seedbed is essential. Weed control before seeding can be obtained with tillage, herbicides, or a combination of both methods. If planting winter canola after wheat, it is critical to control volunteer cereals and cool-season winter annual grasses, but attention must be given to previous herbicide applications.

Pay careful attention when planting most canola varieties following the application of residual ALS-inhibitor herbicides. These products include, but are not limited to, the wheat herbicides Agility SG, Ally Extra SG, Ally XP, Amber, Beyond, Finesse Cereal and Fallow, Glean, Olympus, Peak, PowerFlex HL, Outrider, or Rave; corn or sorghum herbicides Accent, Autumn Super, Basis Blend, Beacon, Hornet, Peak, Permit, Prequel, Priority, Python, Realm Q, Require Q, Resolve Q, Spirit, Steadfast Q, or Yukon; or the cotton herbicides Envoke and Staple (see Table 2). Canola plant-back restrictions may not always be listed on the herbicide label. This is not an indication that it is safe to plant canola. Beware of herbicide residues when a statement following the crop plant-back restriction listing suggests bioassays for all other crops (if canola is not listed). Always refer to the herbicide label.

Several herbicides currently registered in the United States for use on canola can effectively control grass weeds. Trifluralin applied at 0.5 to 1 pound active ingredient per acre or ethalfluralin (Sonalan) at 0.56 to 0.94 pounds active ingredient per acre (depending on soil texture) control numerous weeds. However, they must be mechanically incorporated into the soil 3 to 4 inches deep as part of the last tillage operation. Winter annual weeds for which these herbicides are labeled include henbit (*Lamium amplexicaule*), common chickweed (*Stellaria media*), cheat (*Bromus secalinus*), and downy brome (*Bromus tectorum*) (Photos 28-30). They do not control mustards or volunteer cereals.

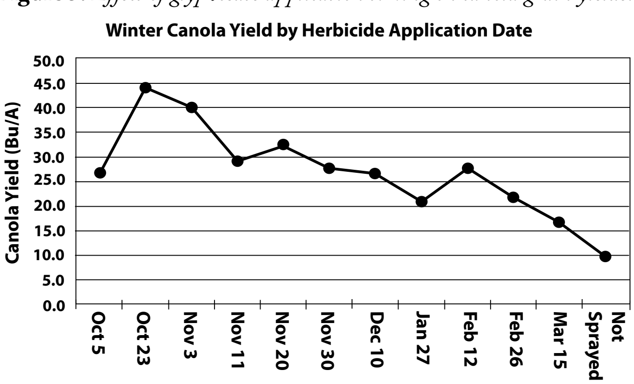
For control of cool-season grasses, apply quizalofop (Assure II or Targa), sethoxydim (Poast), or clethodim (Select Max, many generics) in the fall before the target weeds reach dormancy or in the spring after the weeds begin regrowth. Good control is expected on grass species such as Japanese brome (*Bromus japonicus*), cheat, downy brome, rescuegrass (*Bromus catharticus*), feral rye (*Secale cereale*), jointed goatgrass (*Aegilops cylindrica*), Italian ryegrass (*Lolium multiflorum*), wild oat (*Avena* spp.), and volunteer wheat (*Triticum aestivum*) if label directions are followed (Photos 30-36). Do not graze canola treated with Sonalan, clethodim, or quizalofop. Refer to the product labels to determine whether your target species are listed on the label.

Roundup Ready, or glyphosate-resistant, winter canola varieties and hybrids are available in the Great Plains. This system provides nonselective control of the winter annual grasses listed above and broadleaf weeds including blue mustard (*Chorispora tenella*), bushy wallflower (*Erysimum repandum*), wild mustard (*Brassica kaber*), tumble mustard (*Sisymbrium altissimum*), tansy mustard (*Descurainia pinnata)*, flixweed (*Descurainia sophia*), field pennycress (*Thlaspi arvense*), and shepherd's-purse (*Capsella bursa-pastoris*) (Photos 37-44).

Apply 0.75 pound of acid equivalent of glyphosate per acre to Roundup Ready canola from emergence to just before bolting. Use rates of glyphosate vary among products. For example, the standard use rate for Roundup PowerMax (5.5 pounds active ingredient per gallon, 4.5 pounds acid equivalent per gallon) is 22 fluid ounces per acre. However, for some generic glyphosate products (4 pounds active ingredient per gallon, 3 pounds acid equivalent per gallon), the standard use rate is 32 fluid ounces per acre. Table 15 lists use rates for the various commonly used glyphosate formulations.

Clearfield (imidazolinone) resistant canola hybrids are available that allow the use of imaxamox (Beyond) herbicide for postemergence grass and broadleaf weed control.

Figure 5. *Effect of glyphosate application timing on canola grain yields.*



Beyond may not control weeds that are resistant to ALS-inhibitor herbicides. Be aware that herbicide-tolerant traits are passed on to volunteer canola. This must be considered when selecting herbicides to control the volunteer canola in fallow and subsequent crops.

Effects of Herbicide Application Timing on Winter Canola Yield

The most common mistake with canola weed management is waiting too long in the fall to control weeds. If volunteer wheat or grassy and broadleaf weeds are present, a herbicide should be applied by 4 to 6 weeks after seeding. Waiting for rain to germinate additional weeds is usually a serious mistake. Winter annual weeds that emerge with the canola crop have the greatest effect on yield because canola seedlings do not compete well with weeds.

Herbicide application timing has a strong economic effect on yield. According to Figure 5, the best application timing is early fall before canopy closure to allow the canola to establish successfully. Even though more winter annual weeds may emerge later in the fall and early winter, the weeds that have the most impact on canola yield are the ones that emerge with or shortly after the canola. A second herbicide application in early spring is recommended to control weeds that emerge after the first herbicide application. Field scouting in early spring can determine if a second herbicide application is justifiable. If the goal is to clean up grassy and broadleaf weeds, a second spring herbicide application is recommended. In general, it takes at least 2 years of management to reduce winter annual weeds to a satisfactory level.

Volunteer Canola Control in Winter Wheat

Although volunteer canola has been reported in winter wheat, problems with volunteer canola are not common. The seed has little dormancy and typically germinates after summer rains. It can be eliminated with tillage or with herbicides in no-till production systems. Table 16 provides a general rating for herbicide effectiveness on volunteer canola. These ratings are based on 1 or 2 years of research

Table 15. *Use rates for glyphosate products with various active ingredient (ai) and acid equivalent (ae) concentrations.*

Glyphosate formulation		Glyphosate use rate (0.75 lb ae/acre)[1]
lbs ai/gal	**lbs ae/gal**	**fl oz/acre**
4	3	32
5	3.7	26
5.4	4	24
5	4.17	24
5.5	4.5	22
6	5	20

[1] *Always check the product label for use information. The standard use rate for glyphosate is 0.75 pound of acid equivalent per acre.*

Table 16. *Volunteer canola control in winter wheat.*

Herbicide	Rate unit/acre	Control Rating	
		Fall	Spring
2,4-D ester	1 pt	G-E	P-G
Agility	3.2 oz	E	E
Aim	0.5 oz	VP	VP
Ally Extra	0.5 oz	E	E
Amber	0.56 oz	E	G-E
Beyond	4 oz	G	P-F
Bronate	1 pt	E	F-G
Dicamba	2 fl oz	P	P
Express	0.167 oz	E	G-E
Finesse	0.3 oz	E	G-E
Harmony Extra	0.3 - 0.6 oz	G-E	F-G
Huskie	15 oz	G	P
Karmex 80XP	1.5 lb	---	P
MCPA Ester	1 pt	G-E	F-G
Orion	17 oz	E	G-E
PowerFlex	3.5 oz	E	E
Sencor	4 oz	---	P

E = Excellent, G = Good, F = Fair, P = Poor, VP = Very Poor

where herbicides were applied either in the fall or spring to actively growing canola. All postemergence herbicides were applied with recommended adjuvants.

Volunteer canola will compete with the subsequent crop and may affect yield, depending on the volunteer density. Steps should be taken during swathing and combining operations to minimize canola seed losses. For no-till small grains, consider adding a labeled herbicide to the glyphosate burndown application to control emerged glyphosate-resistant volunteer canola. Volunteer canola that emerges before or with the crop may be large by the time the postemergence herbicide application is made.

Volunteer canola becomes much more difficult to control with herbicides once plants reach the 6-leaf to bolting stage. Some herbicides may provide excellent control of small volunteers but poor control of volunteers that have bolted. Volunteer canola will be controlled best when the herbicide is applied by the 3- to 5-leaf stage and the canola plants are actively growing. Dormant canola is much more difficult to control since it is not actively growing.

Plant Responses to Herbicide Carryover and Drift

Many factors can cause differences in the appearance of canola plants that are not usually reason for major concern. Differences in size and color may be caused by soil type, fertility, previous crop, variety of canola planted, and winter weather. Nonetheless, producers should be alert to symptoms of low pH effects (Photo 2), nutrient deficiencies (Photos 17 – 27), herbicide injury (Photos 45 - 48), and diseases (Photos 49 – 69), because these factors are most often yield limiting.

Synthetic auxin and ALS-inhibitor herbicides can cause significant injury to canola from herbicide drift or spray tank contamination. Before spraying canola, always be sure that filters, spray tip screens, and herbicide-handling equipment are free of herbicide residues that may injure canola. It is a good strategy to inform local custom applicators and neighbors of canola fields nearby, and remind them that canola is susceptible to drift from herbicides applied to wheat, pastures, and rangeland. Remember wheat is susceptible to many herbicides applied to canola.

Herbicide residue and drift are more common in areas with inexperienced producers and pesticide applicators. Symptoms include, but are not limited to, stunting, chlorosis, discoloration, malformed leaves, root pruning, and plant death. ALS-inhibitor herbicides, such as Ally, Amber, Finesse, Olympus, Osprey, and PowerFlex can severely injure canola (Photo 46). Many ALS-inhibitor herbicides persist longer in soils with low organic matter and pH greater than 7.5. Herbicide carryover also can be affected by soil texture, drought, temperature, and herbicide use history. Glyphosate must not be applied to non-Roundup Ready canola (Photo 47). Damage from herbicide drift or tank contamination is generally from ALS-inhibitor and synthetic auxin herbicides like 2,4-D, MCPA, dicamba, and Tordon (picloram). Photo 48 shows typical damage from drift or sprayer contamination of synthetic auxin herbicides. In the field, symptoms appear about 5 to 10 days after exposure. Symptoms may include swelling above and within the crown, swelling and twisting of the stems, and severe twisting of the main stem. Chlorosis of the leaves will be noted with time.

Cleaning Field Sprayers to Avoid Canola Injury

With the use of herbicides that are active at low application rates, proper cleaning and maintenance of sprayers is necessary to avoid injury to canola. This is important as more producers use nonselective herbicides such as glyphosate on herbicide-tolerant crops. Postemergence applications sprayed directly on crop foliage have greater potential for crop injury than soil applications. Serious crop injury can result from small amounts of herbicides remaining in the sprayer system. Herbicide residues in the sprayer can be dissolved with contact from other herbicides, solvents, and adjuvants. Residues can accumulate in cracked hoses.

When cleaning a sprayer, pay careful attention to buildup area, sumps and pumps, tops of tanks, baffles, and irregular surfaces. Select cleaning agents based on the herbicide and formulation used. Commercial tank cleaning agents, household ammonia, and detergents remove both water and oil soluble herbicides and are recommended on most herbicide labels. All sprayer components, including the tank, pump, hoses, and nozzles must be thoroughly cleaned to avoid contamination.

Cleaning procedures for specific herbicides

Dicamba (Banvel, Clarity, others), 2,4-D (amine and ester formulations)

1. Fill tank half full of water, then flush all water out of the sprayer.
2. Fill tank with water and add 1 quart of household ammonia for every 25 gallons of water in the tank. Operate the pump to circulate for 15 to 20 minutes and spray a small amount of solution out of the boom. Let stand overnight.
3. Flush water out of the spray tank through the boom.
4. Remove nozzles and screens and flush system with two full tanks of water.
5. Repeat step one.

Ally, Assure, Finesse, Glean, Harmony Extra, Poast, Select

1. Flush tank and boom with clean water for at least 5 minutes.
2. Partially fill the tank and add 1 gallon of ammonia for every 100 gallons of water in the tank. Flush a small amount of the cleaning material through the hoses, boom, and nozzles. Fill the tank and circulate the solution for 15 to 20 minutes. Let stand overnight.
3. Flush water out of the spray tank through the boom.
4. Remove nozzles and screens and clean separately with cleaning agent.
5. Rinse the tank with clean water and flush it through the hoses and boom.

Diseases

Canola is a member of the mustard family (*Brassicaceae*, formerly *Cruciferae*), which includes common weeds such as mustards, pepperweed (*Lepidium virginicum*), and shepherd's purse (*Capsella bursa-pastoris*). Diseases that affect these weeds also may affect canola. Diseases attack canola at all stages of development. They can be soilborne, seed borne, airborne, or spread from infected crop residues.

Blackleg

The recent identification of blackleg, caused by the fungus *Leptosphaeria* spp., in the region suggests that disease incidences will likely increase as canola acres increase. Blackleg is a common disease worldwide that affects canola and related crops. Blackleg is the most serious threat to canola production. The disease creates stem cankers and basal stem decay that causes lodging and premature death and reduces plant growth and yield.

There are both mild and aggressive species of the fungus. The aggressive species (*Leptosphaeria maculans*) was first reported in Saskatchewan in 1975 and then again in Kentucky in 1989. It has subsequently spread across Manitoba and Alberta and into North Dakota, Tennessee, Indiana, Illinois, and Michigan. The aggressive species was first identified on several farms in Kansas and Oklahoma in 2009 and is now widespread in production areas of the state where there is a history of canola production. The mild species (*Leptosphaeria biglobosa*) also has been found in Oklahoma, but is less common.

The blackleg fungus survives between canola crops in infected seed, stubble, and on certain weeds. Long-distance spread of the disease occurs when over-summering spores, known as ascospores, are released from infested stubble. Ascospores can travel on air currents for many miles, but most spread within 1,000 feet of infested stubble.

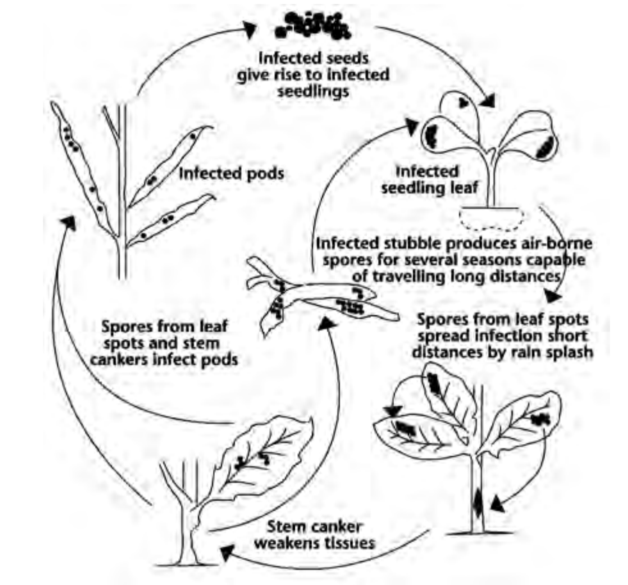
Ascospores typically cause leaf spots on seedling and rosette stage canola during the fall and winter. On newly infected plants, a second spore type, called conidia, are released and dispersed by splashing rain from small, black, pimple-like structures known as pycnidia. Conidia are responsible for increasing disease pressure on leaves, stems, and seedpods and infecting neighboring plants. Blackleg is thought to be introduced into new areas with infected seed.

Infections from the mild species usually occur much later in the season than those from the aggressive strain. Shallow, white to gray lesions will form on the leaf or stem, but stems are usually not girdled. Only a few pycnidia are formed. In contrast, the aggressive species can infect early and produce leaf spots as well as stem lesions. Leaf spots (Photos 49-50) are round to irregular in shape and are usually tan to buff in color with many pycnidia present.

Stem infections are usually first observed as inconspicuous bluish lesions at a petiole scar near the soil line. Later, these lesions develop into an elongated, light-brown sunken area with a purplish or black margin. As the lesion gradually lengthens, the stem becomes girdled and blackened (Photo 51). Pycnidia form in the stem lesions, often at the stem base where a leaf was attached. Severely infected plants die prematurely and significant lodging often occurs. The blackleg cycle is illustrated in Figure 6.

The most important management method to control blackleg is excluding it from an area. This is accomplished by planting only disease-free, certified seed that has been treated with a fungicide effective against blackleg. Several seed treatment products are registered for control of seed-borne blackleg including Acceleron IDL 810 and Helix XTra (difenoconazole + metalaxyl-M + fludioxonil + thiamethoxam); Helix Vibrance (difenoconazole + metalaxyl-M+ fludioxonil + thiamethoxam + sedexane); Dynasty (azoxystrobin); Obvious (fluxapyroxad + pyraclostrobin

Figure 6. *Blackleg cycle.*



+ metalaxyl); Prosper FX (clothianidin + trifloxystrobin + carboxin + metalaxyl); Prosper Evergol (clothianidin + penflufin + trifolxystrobin + metalaxyl); and Rancona RS (carboxin + ipconazole). However, seed treatments will not provide disease control where canola is planted in or near infested stubble.

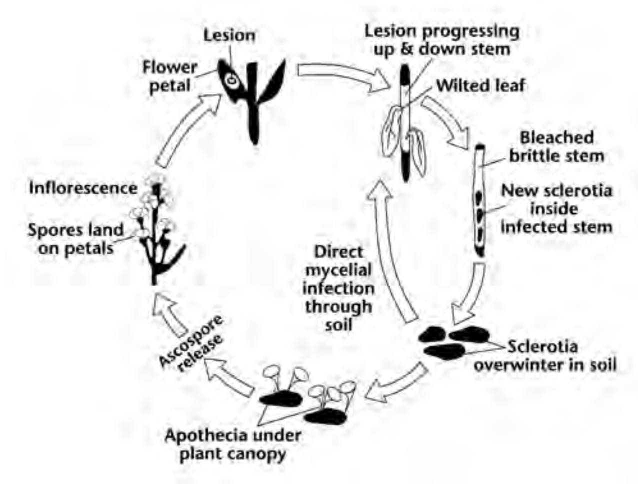
Deep tillage has been used to bury infested crop residue and reduce levels of blackleg. If tillage is not possible, reduce the amount of residue by burning or management practices that hasten its decomposition. Another approach would be to exclude canola from fields with infected stubble for 3 to 4 years to allow sufficient decay. Control of volunteer canola and wild *Brassica* species is also highly recommended.

Genetic resistance and crop rotation are the two best methods for managing the disease once it is present. Resistant varieties are available and most varieties developed in the Great Plains possess some resistance. Consult local seed dealers and university publications for disease ratings.

Sclerotinia Stem Rot

Sclerotinia stem rot is caused by the fungus *Sclerotinia sclerotiorum*. It is a serious problem in many areas throughout the world. Sclerotinia, also known as white mold, is most severe when warm, wet conditions occur during the flowering period. The fungus has a wide host range including field crops such as dry beans, sunflowers, and soybeans. It is important to include significant time between susceptible crops when canola is in the rotation. Frequent rotation with these crops may cause a rapid buildup of the disease in the soil. Sclerotinia is present throughout the Great Plains and its occurrences may increase as canola acres increase. So far, its impact has been minimal except for occasional outbreaks in sunflowers, dry beans, and soybeans under irrigation on the High Plains where cooler nighttime temperatures favor its development.

Figure 7. *Sclerotinia stem rot cycle.*



The first noticeable symptom of Sclerotinia stem rot is the presence of prematurely ripened plants (Photo 52). Under high moisture conditions, a white moldy growth may develop on the surface of stems and pods. Stems become bleached and tend to shred (Photo 53). Hard black structures (Photo 54) known as sclerotia appear in or on the stems near the soil line as well as on infected pods. Sclerotia fall to the ground at harvest or when the stems break from lodging. During the spring, sclerotia near the soil surface germinate to produce small golf-tee shaped structures known as apothecia (Photo 55). Apothecia release ascospores during wet weather and periods of heavy dew. Spores are carried on air currents and infect flower petals. Infected petals fall on leaves or stems, which in turn become sites for the fungus to invade the plant. Symptoms of stem rot appear approximately 10 to 14 days after infection. The disease cycle of Sclerotinia stem rot is shown in Figure 7.

Prevention is the best means of control. Practice crop rotation with nonhost grass crops, such as wheat, for at least 3 to 4 years. Once *S. sclerotiorum* is present in the soil, deeply buried sclerotia remain dormant for 8 or more years, and can be brought near the surface by cultivation. To reduce the incidence of conditions favorable for *S. sclerotiorum* infection, use lower plant densities to facilitate air movement, light infiltration, and drying. If possible, time irrigations to keep the soil surface dry during flowering in order to minimize disease risk. Foliar fungicide treatments can be effective, but timing is critical; make applications at the early- to mid-bloom stages. Aproach (picoxystrobin), Endura (boscalid), Priaxor (pyraclostrobin + fluxapyroxad), Proline (prothioconazole), Propulse (fluopyram + prothioconazole), Quadris (azoxystrobin), and Quash (metconazole) are registered for use in managing sclerotinia stem rot.

Alternaria Black Spot

The fungal disease known as Alternaria black spot (caused by various species of *Alternaria*) is widespread and is worse in wet years when seed yields can be significantly reduced by pods splitting or early death of the plants. All aboveground parts of the plant are susceptible. Black, brown, or gray spots on the leaves, stems, and pods are the most common symptoms (Photos 56-57). Often the spots are surrounded by a light-green or yellow halo.

Alternaria survives in infested crop residue, on infested seed, and on some alternative weed hosts. Infested seed either rots in the soil or produces infected seedlings. Windblown spores germinate, penetrate plant surfaces, and cause lesions within a few days. These lesions produce more spores, which cause new infections on the same or neighboring plants.

Control is achieved by sowing clean, disease-free seed. A rotation of 3 years between canola crops, controlling susceptible weeds, and controlling volunteer canola reduce the incidence of this disease. In a heavily infested crop, swathing or timely harvest reduces shattering caused by Alternaria.

Winter Decline Syndrome

Winter decline syndrome can reduce canola stands in the late winter and early spring. Winter decline syndrome begins with physical injury to roots, crowns, and stems. The injury may be caused by premature bolting, bitterly cold temperatures, soil heaving, or waterlogged soils. As a result, numerous plant pathogens including *Fusarium* spp., *Rhizoctonia* spp., and *Xanthomonas* spp. may infect the injured plants. As warmer temperatures return, plants appear to bolt normally, but then turn bluish-green and wilt as flowering begins. Some affected plants remain healthy-looking but eventually lodge due to weakened crowns. Others remain standing only to die prematurely, significantly reducing yield.

Large, swollen crowns are a signal that winter decline syndrome may be present (Photo 58). Stems and roots of affected plants are hollow and rotten when pulled from the ground (Photo 59). Oftentimes root maggots (*Delia* spp.) are present (Photo 60). The best management strategy is to plant a winter-hardy variety at the optimum planting date (Photo 61). Winter decline syndrome tends to be a problem in climates where rapid fluctuations in winter temperatures are common. The best management practices for avoiding winter decline syndrome are to plant a winter-hardy variety on time and to avoid waterlogged soils. Varieties that break winter dormancy early following a warming period and varieties developed outside the southern Great Plains may show the greatest susceptibility.

Verticillium wilt

The cause of verticillium wilt is a soil-borne fungus *Verticillium dahliae* Kleb. Initial symptoms are observed at flowering with a yellowing or bronzing of one side of the leaves; however, the disease is easiest to identify at maturation and on crop residue. Light brown streaks appear on one side of the stem confirming infected xylem tissues underneath (Photo 62). These tissues effectively collapse and contract. Dark gray and black microsclerotia are formed inside the roots and stem base (Photo 63). The microsclerotia, having the appearance of iron filings, also form on the surface of the stem turning it gray and black. The main root will show gray to black streaks and the lateral roots will be fully decayed, allowing the plant to be pulled with ease. This is different symptomology than blackleg where the lateral roots remain uninfected. Affected plants ripen prematurely and can lodge easily. At ripening, the asexually produced microsclerotia fall to the ground where they remain viable for several years. Mycelium from microsclerotia are the main source of infection to subsequent canola crops.

Downy Mildew

The downy mildew fungus, *Peronospora parasitica*, causes yellow, irregular patches on upper leaf surfaces, giving the leaf a stippled appearance. Undersides of leaves exhibit yellow patches with a white, granular appearance. Sparse webs of fungal growth occasionally occur on stems and pods (Photo 64). Little damage is caused by spring infection, but occurrence of the disease in the fall reduces winter survival. Losses from this disease are rare in the Great Plains.

Powdery Mildew

The powdery mildew fungus, *Erysiphe cruciferarum*, causes a white, dusty growth on aboveground plant parts (Photo 65). The disease is favored by moderate temperature, high humidity, excessive nitrogen fertilization, and excessive canopy density. In some production areas where canola is widely grown, powdery mildew results in serious yield losses. The disease is thought to be of minor importance in most areas of the Great Plains at this time although its severity in increasing.

Black Rot

Black rot is a bacterial disease caused by *Xanthomonas campestris*. Infected leaves have a bright yellow discoloration on their margins and dark veins in infected areas (Photo 66). This bacterium is seedborne and overwinters in infested stubble. The symptoms of black rot are quite visible (Photo 67) and the disease has become common in the Great Plains, but does not appear to be damaging.

Seedling Disease Complex

Seedling diseases are characterized by failure of seeds to germinate, poor emergence, or loss of established seedlings. Damping-off of young seedlings, which resembles the pinching of the stem at or just below the soil line, is caused by several fungi including *Pythium* spp., *Fusarium* spp., and *Rhizoctonia* spp. (Photo 68). Symptoms occur when seeds are planted under adverse conditions, especially excessively cool and wet soils, and results in thin, patchy stands. Losses are rarely serious. Control starts with the use of certified seed planted shallowly into a firm, moist, warm seedbed. Use of a fungicide seed treatment, including those recommended for blackleg, is also beneficial.

Aster Yellows

Aster yellows is caused by a phytoplasma (a bacteria-like, plant-pathogenic microorganism). This organism has a wide host range and infects about 300 species of plants. Plants infected with aster yellows fail to set pods, producing blue-green, sterile, hollow bladders in place of normal pods (Photo 69). Infected plants remain in a vegetative state during the entire growing season and remain greener and sometimes taller than uninfected plants at harvest. Aster yellows is spread from plant to plant by the aster leafhopper (*Macrosteles quadrilineatus*) (Photo 100) in the fall or spring. No disease management strategies are available, but generally fewer than 2 percent of plants are infected. Aster yellows is common throughout the southern Great Plains and is worse in some years.

Nematodes

Canola is susceptible to both sugar beet cyst nematodes and false root-knot nematodes, so rotating canola with sugar beets should be avoided. No other nematodes are known to cause economic losses to canola.

Insect Pests

Winter canola attracts many insect pests. Some feed on canola and mustards only, while others have a wider host range. Insect pests of canola can reduce yields by defoliating plants, damaging flower buds or seedpods, or damaging crowns and roots. Others transmit plant pathogens such as aster yellows virus. Seedling canola is especially vulnerable to chewing insects, because plants die if the aboveground portion is completely eaten. Damage caused by insects is more severe when canola is under stress, especially drought stress. Canola pests can occur throughout the entire growing season (Table 17). Because canola is still a relatively new crop to the southern Great Plains, information on some insect treatment thresholds is limited. For current insect-control recommendations, see Table 24 on page 39.

If an insecticide application is necessary, select the insecticide carefully and consider product selection and application timing options that help protect pollinating insects and natural enemies. At flowering, consider applying an insecticide in the evening when honeybees are not actively foraging to avoid killing them, and notify any beekeepers if they have hives nearby. Cultural practices such as crop rotation, controlling volunteer canola, treating roadside ditches and fencerows for related species, and incorporating plant residue into the soil are important means for preventive management of canola insect pests. As canola acres increase in the region, insect problems will likely increase, but so will the availability of management options. Watch for alerts of local pest outbreaks and review management guides and chemical labels regularly.

Several insecticides and seed treatments are registered for use in canola. Insecticides containing *Bacillus thuringiensis* (Dipel and other trade names); bifenthrin (Capture and several other trade names); chlorantraniliprole (Coragen); cyantraniliprole (Lumiderm); deltamethrin (Decis); flonicamid (Carbine); gamma-cyhalothrin (Proaxis and Prolex); lambda-cyhalothrin (Warrior and other trade names); sulfoxaflor (Transform); zeta-cypermethrin (Mustang MAXX); and seed treatments containing clothianidin (Poncho); clothianidin + thiram + carboxin + metalaxyl (Prosper); and thiamethoxam + difenoconazole + mefenoxam + fludloxonil (Helix XTra) are available. For specific information on products, rates, and other information, check with your local county extension office and refer to the labels of specific registered products.

During the past decade, several pests of canola have emerged in the southern Great Plains, including aphids, army cutworms, corn earworms, diamondback moth larvae, flea beetles, grasshoppers, root maggots, and false chinch bugs.

Table 17. *Scouting calendar for insect pests at various winter canola development stages.*

September – October	**November – February**	**March**	**April**	**May – June**
Seedling to Rosette	**Late Fall to Over-winter**	**Rosette to Bolting**	**Flowering to Pod Development**	**Pod Development to Harvest**
Cutworm	Cutworm	Cutworm	Cabbage Aphid	Cabbage Aphid
Green Peach Aphid	Green Peach Aphid	Green Peach Aphid	Green Peach Aphid	Green Peach Aphid
Turnip Aphid	Turnip Aphid	Turnip Aphid	False Chinch Bug	False Chinch Bug
Diamondback Moth Larvae	Diamondback Moth Larvae (check plant crowns)	Diamondback Moth Larvae	Lygus Bug	Lygus Bug
				Variegated Cutworm
Flea Beetle				Armyworm
Grasshopper				Seed Pod Weevil
				Harlequin Bug

Aphids

Aphids are the most important insect pests of canola in the southern Great Plains. The green peach aphid (*Myzus persicae*) and the turnip aphid (*Lipaphis erysimi)* (Photos 70-71) frequently colonize fields during fall, survive mild winters, and increase to damaging levels in early spring. Green peach and turnip aphids feed on the underside of canola leaves, while the cabbage aphid (*Brevicoryne brassicae*) (Photo 72) usually colonizes the terminal buds late in the season.

Predatory and parasitic insects contribute to aphid population control, but alone have not been observed to prevent aphids from reaching damaging levels. During and following mild winters, aphid populations become numerous enough to cause significant stand decline and reduce seed production. The consistent occurrence of fall aphid infestations, coupled with their potential to cause damage, clearly suggests that an insecticide seed treatment be used as an important preventive management tactic. Seed treatments using clothianidin, imidacloprid, or thiamethoxam effectively reduce fall aphid infestations but will not prevent buildup when growth resumes in spring or stop aphids from infesting flowering racemes and developing pods.

Regular scouting is the best method to monitor the effectiveness of seed treatments during the fall. Use this scouting to assess the need for treating spring infestations. If populations are high from January through March, an insecticide treatment may be necessary. It is important to note that canola can recover from aphid infestations following timely insecticide applications. Occasionally, producers have experienced poor control of green peach aphids in canola. Green peach aphids are known to develop resistance to many insecticides, especially pyrethroids (group 3 insecticides).

Directions for sampling green peach or turnip aphids in winter canola

1. Walk diagonally across the field and stop 10 times.
2. Check three plants at 10 stops (30 plants).
3. Count aphids on three consecutive plants.
4. Make sure to flip the leaves over and check, especially leaves closest to the ground (Photo 73).
5. Note other spots with dead or dying plants.

Cabbage aphids in the flower cluster

During flowering, cabbage aphids feed and reproduce on the stalk inside the cluster of flower buds, which makes it difficult for ladybugs to find and eat them. When scouting, it is often necessary to push the flower cluster open with your fingers to find these aphids. Damage to flower buds and flowers prevents pod set and can severely reduce yields. If aphids are present on plants throughout the field and threaten flower and seed production, insecticide treatment is recommended. Cabbage aphids can reproduce and spread quickly, so it is important to regularly scout your fields during flowering. Treat at the bud, early bloom, and full bloom stages when infested stems (racemes) exceed 15 percent.

Table 18. *Green peach and turnip aphid management levels to prevent economic yield losses.*

Canola Price ($/lb)	Aphids/Plant*
0.30	50 – 100
0.25	60 – 120
0.20	70 – 140
0.15	80 – 160
0.10	90 – 180

**Lower numbers during dry conditions*

Treatment (action) thresholds

Use the treatment thresholds in Table 18 to prevent aphids from causing economic losses. An average of one aphid per plant can reduce yields by 0.5 pound of seed per acre. Before flowering, canola can tolerate large numbers of aphids before an insecticide application is justified. It is important to delay insecticide use until the treatment threshold has been reached. Use of insecticides on low aphid densities results in net dollar losses. Delaying the first insecticide application reduces the likelihood that a second or third application will be needed.

Army Cutworm

Canola is especially palatable to army cutworms (*Euxoa auxiliaris*) (Photo 74). Cutworms are a natural part of the prairie habitat. Some cutworms are likely to be in most crop fields in any given year, but usually at levels well below where they would be an economic concern or worth trying to manage. However, some species of cutworms can reach economically damaging levels in canola in some years.

Adult army cutworm moths prefer to lay eggs in bare soil, so later-planted fields, or fields that have not established cover are more vulnerable to infestations. They may lay several hundred eggs in or on the soil surface. After the eggs hatch, the larvae feed on host plants. Larvae normally have six instar stages before they become fully grown. Army cutworm damage can be observed in the late fall and about the time that plants break dormancy in early spring.

Army cutworms can be difficult to find because they feed at night and hide during the day. Cutworm damage is characterized by leaves or whole plants cut off at or near the soil surface. Plants appear notched, wilted, cut-off, or dead (Photo 75). Cutworm feeding may cause missing plants and bare patches in fields. Feeding may be in multiple patches or specific areas of the field. Cutworm infestations may be worse in sandy soils.

When scouting, it is important to search six to 10 random locations in a field and dig into the soil around canola plants a few inches deep. Plants and leaves cut off at the soil surface are a good indication that army cutworms are present. Consider treatment when populations reach one to two per square foot and are causing stand loss and/or severe damage to established plants. The cutworms may be located from ¼ to 4 inches deep depending on soil moisture, soil temperature, and age of the larvae.

Diamondback Moth

The larvae of the diamondback moth *(Plutella xylostella)* frequently infest canola in the southern Great Plains (Photo 76). These larvae are small, green foliage-feeding caterpillars that wiggle violently when disturbed. If present, they produce windowpaning and shot holes in the leaves (Photo 77).

Diamondback moths are found worldwide. The moths are small, grayish-brown, and measure ½ inch long. When resting, the wings fold over the body in a roof-like position. Male moths have three diamond-shaped markings on their folded forewings (Photo 78). Female moths lay flattened, oval-shaped eggs measuring 0.017 inch in groups of one to eight eggs, which will hatch in 5 to 6 days. One female will lay an average of 150 eggs.

Newly hatched larvae are light green with a green head and become progressively darker as they mature. They develop through four instars and reach ½ inch long when fully grown. Larvae pupate in a loose, silken cocoon attached to the plant. They can complete a lifecycle in about 32 days, depending on temperature. Generally, all instar stages are found in a field at the same time. When larvae first hatch, they feed by leaf mining and chew small, irregular windowpanes on leaves. As they grow larger, they can consume entire leaves leaving only the veins.

Diamondback moth larvae often attack larger canola first, but are usually found in most canola fields in the fall. These larvae may overwinter and feed in the crown of canola plants; this may be the only habitat available for small larvae in a cold winter. High caterpillar infestations in the crown may result in stand loss and can easily be mistaken for winterkill. Malformed leaves that emerge from the crown due to larval feeding also may be noted.

Begin scouting fields for diamondback moth larvae following seedling emergence. In the fall, diamondback moth larvae and aphid populations develop earlier if a seed treatment was not used. Scout for larvae by pulling a few plants and tapping the crowns on a piece of white paper. Control should be considered if foliage damage is significant. If scouting in the winter shows heavy crown infestations, spraying for control is recommended. Infestations have been high enough to kill entire fields.

The suggested threshold is two to three larvae per foot of row at the seedling stage. One caution: diamondback moths are infamous for developing resistance to insecticides, particularly pyrethroids, which are the primary registered insecticides for use in canola. Therefore, use the high end of any labeled rates to eliminate the possibility of poor control and rotate modes of action.

Flea Beetles

Generally, flea beetles (*Phyllotreta* spp.) (Photo 79) are less of a problem with winter canola in the southern Great Plains. Flea beetles attack the cotyledons at emergence and the first true leaves of seedlings producing pits or shot holes in leaves. Seedlings can withstand 50 percent damage to the cotyledons without suffering any loss of yield potential. However, heavy populations can occasionally cause stand reductions. Overwintering flea beetles attack canola in the spring, but they rarely cause economic damage because foliage is abundant.

Grasshoppers

Grasshoppers are a problem at seedling emergence. When populations are high, grasshoppers migrate into emerging stands and devour the cotyledons. Damage is usually limited to the field margins.

Root Maggots

Root maggots are the larvae of a fly (*Delia* spp.) (Photo 80). They can become a problem on canola during cold, wet growing seasons. Maggots damage the inside of the stem at the soil level and infested plants may easily lodge. Infested plants are often infected with secondary fungi. Insecticidal seed treatments can suppress populations in the fall; however, spring populations are difficult to control. In northern growing regions, delayed planting combined with higher seeding rates appears to reduce economic damage. Because the adult flight period is long, springtime insecticide applications are not economical. Infestations may be reduced by controlling related mustards that serve as hosts for the maggot.

False Chinch Bugs

False chinch bugs (*Nysius raphanus*) sometimes occur in large numbers during mild, dry growing seasons (Photo 81). Severe damage has been observed in the southern Great Plains and it often results when false chinch bugs infest racemes during bloom and early pod set. Under dry conditions, the populations can reach economic thresholds quickly. Typically, populations remain low until late in pod set when the pod walls are thick enough to limit false chinch bug damage.

False chinch bugs spend the winter among annual mustard host plants. Mustard family plants are particularly favored by false chinch bugs; however, they may feed on a wide variety of hosts, including potato, kochia, lettuce, pigweed, quinoa, and turf grass. The largest infestations of false chinch bug are usually found on plants that are flowering or producing seed. Flixweed (*Descurainia sophia*) is an important winter host for this insect.

When temperatures warm sufficiently to allow development, eggs are laid around the base of plants. The nymphs are smaller than adults, wingless, and more oval-shaped. They are gray colored, and a red marking is often observable on their backs. As the nymphs feed and molt, wing pads become noticeable. Multiple generations are produced during a single growing season.

False chinch bugs feed by sucking sap from plants. If populations are low, their feeding is not destructive and little if any injury is observed. However, they often swarm in groups with thousands of individuals (Photo 82). Leaf dieback, reduction in plant height, flower bud abortion, and wilting may occur under these conditions, particularly when plants are under drought stress.

Thoroughly scout canola fields and count the number of false chinch bugs feeding on a single raceme; the thresholds are 5 to 10 per raceme at flowering and 10 to 20 per raceme at pod set. If thorough scouting is not possible or the insects are swarming aggressively, treat canola when 20 to 30 per plant at flowering, or 40 to 50 per plant at early pod set, are present. As a general rule, the term "clouds" has been used to describe heavy infestations of adults swarming in the air. If populations reach this level, it is advised to spray. During dry weather, false chinch bugs are difficult to control. It is critical that fields are sprayed with as much water carrier as possible to obtain adequate coverage. Ground applications are suggested in order to spray at the higher spray volumes. For aerial applications, use a minimum of 5 gallons per acre to achieve the best control.

Fall Armyworms

Once canola has emerged, scout for fall armyworms. Examine plants in five or more locations in the field (Photo 83). Fall armyworms are most active in the morning or late afternoon. Look for windowpanes on leaves and count all sizes of larvae. Examine plants along the field margin as well as in the interior because fall armyworms often move in from road ditches and weedy areas. Look for windowpane damage in young canola plants or cut plants. At the seedling stage, do not allow fall armyworms and cutworms the chance to reduce stand.

Occasional Pests

The following are known pests of canola, but they do not consistently threaten winter canola in the southern Great Plains. The **cabbage seedpod weevil** (*Ceutorhynchus assimilis*) is a severe pest in Europe and portions of the United States (Pacific Northwest and Southeast) (Photos 84-85). The adult weevil is attracted to the yellow color of canola flowers and attacks young seedpods during and after bloom. Female weevils lay eggs inside pods, and the developing grubs feed on the maturing seeds. High infestations cause losses of 20 to 30 percent. The economic threshold is two weevils per plant at flowering.

Imported cabbageworms (*Pieris rapae*), **southern cabbageworms** (*Pontia protodice*), **alfalfa loopers** (*Autographa californica*) and **cabbage loopers** (*Trichoplusia ni*) defoliate canola plants in the fall and spring (Photos 86-90). Economic thresholds are not established, but damage is usually minor and yield loss minimal if the plants are healthy and growing vigorously. **Beet armyworms** (*Spodoptera exigua*) can attack fall-seeded canola (Photo 91). Watch for larvae and treat if stands are threatened. **Corn earworm (***Helicoverpa zea***)** and **variegated cutworm (***Peridroma saucia***)** occasionally occur in spring and cause damage to seed pods (Photos 92-93). Economic thresholds are two or more caterpillars per square foot. **Harlequin bugs** (*Murgantia histrionica*) (Photo 94) and **June beetles** *(Phyllophaga* spp.*)* (Photo 95) are occasionally numerous in canola fields at harvest, but thresholds are not well established. **Lygus bugs** (*Lygus* spp.) feed and lay eggs on canola during budding (Photo 96). Damage includes flower abortion and poor pod set with small, shriveled seeds. Two generations per year are possible in the southern Great Plains. **Red turnip beetles** (*Entomoscelis americana*) are an occasional pest of spring canola in the northern United States and Canada (Photo 97). They can damage seedpods of mature plants. **Thrips** (various species) rasp leaf tissue and flowers, and may cause wilted flowers and curled or distorted pods (Photo 98). **Wireworms** are the larvae of various species of click beetles and can be a potential pest as they are in many other crops (Photo 99). They can be managed with seed treatments if problems are anticipated before planting. **Aster leafhopper** (*Macrosteles quadrilineatus*) causes the spread of aster yellows (Photo 100). No treatment thresholds are available. **Bird damage** can severely reduce yields; areas close to large flocks of geese, blackbirds, pigeons, and finches should be avoided.

Grazing

For centuries, rapeseed has been used as high-quality, annual forage in Europe. Canola's potential as a dual-purpose forage and grain crop in the Great Plains is being evaluated. Preliminary research shows that canola produces a highly digestible, nutritious forage, but grazing canola in the fall reduces grain yield by 30 to 50 percent and grazing canola in the spring reduces grain yield by 70 percent. For this reason, grazing is not recommended where the production objective is to produce a high grain yield. Also, the forage produced by treated canola seed cannot be grazed according to product labels. Thus, if canola forage will be grazed, then the seed must be untreated.

In simulated grazing trials conducted by Kansas State University over a 3-year period, varietal differences in grain yield have been observed. Experimental varieties with prostrate rosettes yielded similarly to ungrazed check varieties. Thus, new dual-purpose varieties are being

Table 19. *Canola forage feed values compared to wheat forage.*

Cultivar	Forage	Protein (%)	ADF (%)	NDF (%)	NEM (Mcal/lb)	TDN (%)	RFV (%)
Griffin	Canola	26.7	20.7	25.7	0.85	74.5	281
Wichita	Canola	28.5	18.9	23.6	0.88	76.6	311
Karl 92	Wheat	23.7	26.1	42.1	0.77	68.1	160

ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; NEM = Net Energy Maintenance; TDN = Total Digestible Nutrients; RFV = Relative Feed Value

developed. One such variety, 'Griffin', was released in 2013 and is now available to producers.

Canola forage is slightly higher in protein, lower in fiber, and higher in energy than wheat (Table 19). When grazing canola, no more than 75 percent of the ration should be canola with the other 25 percent consisting of a lower quality, high-fiber hay. Nutritionists recommend that canola forage should be treated as a concentrate rather than a forage crop. Since canola is relatively low in fiber, producers should exercise caution when introducing cattle to canola pasture and may want to consider a bloat preventative. Cattle should be full, near a source of fiber, and closely monitored when placed on canola pasture.

Producers in the region report cattle develop a taste for canola after a few days and noticeably devour the crop before moving to new forage. Other producers notice cattle are not interested in the crop until after a hard freeze. Research has shown that total digestible nutrients increase by 4 to 5 percent and relative feed value increases by 40 to 80 units after a series of hard freezes. Also, energy values increase, fiber decreases, and crude protein decreases by 1 to 3 percent.

To obtain a better use of the crop, graze canola with younger cattle rather than older cows. Younger, smaller animals cause less physical damage to the crown of canola. It is critical to monitor winter canola for nitrate content before and during grazing. High nitrates may be found in stems and lower plant parts. Thus, after cattle remove the leaves and begin feeding on other plant parts, the risk for nitrate poisoning increases. Research has shown that nitrate content decreases significantly following a series of hard freezes.

Management guidelines for canola as a dual-purpose crop are limited at this time. Different canola varieties produce varying amounts of fall forage for grazing. A slightly earlier planting date is advisable, but adjustments to seeding rates may not be necessary. Stock the canola field when the canopy height is approximately 6 to 10 inches tall. Generally, the most forage is available when reaching the eight-leaf stage when the canola is growing vigorously. Adjust the stocking rate so new growth is consumed and remove the cattle when half of the original forage remains. Canola grazing can be viewed as opportunistic because the availability and duration of canola forage is more weather dependent than for winter cereals such as wheat and rye. Therefore, producers should not rely on canola as the primary part of their grazing program.

Harvest

Canola can be swathed, desiccated, or pushed to assist with harvest, or it can be harvested directly. Determining which option to use is a management decision for the grower because all can be done successfully if performed correctly.

Ripe canola should be harvested immediately as preharvest shattering can be a problem. Equipment should be ready to harvest canola just as soon as the crop is at 8 to 10 percent moisture content. Canola should be harvested before wheat, otherwise crop losses may occur. Losses from pod shattering due to high winds, heavy rain, and hail can be large, resulting in yield losses greater than 50 percent. Harvesting canola is a slower process than harvesting wheat.

Producers who successfully harvest canola say that experience leads to success. If harvesting for the first time, check combine settings every few acres. This allows for experimentation with one's own equipment.

Swathing

When swathing, it is important that the plant is at the correct stage of maturity. For optimum seed yield and oil quality, the best time to swath is 40 to 60 percent seed color change, which is observed on the main raceme. The seed moisture content will be 30 to 40 percent. Canola can be swathed at 30 to 70 percent seed color change without sacrificing significant yield or quality; this provides a wider window for producers. In hot, windy, and dry conditions, canola matures quickly and seed color change can increase by 10 or more percentage points in fewer than 3 days.

Swathing involves cutting and placing the crop in windrows directly on the cut stubble for approximately 5 to 10 days or until the seed moisture is below 10 percent (Photo 101). At this time, the canola can be harvested with a pickup header. It is a good option if the crop maturity is uneven across the field.

Swathing helps reduce shatter losses from wind and hail by getting the crop out of the field quicker. Swathing terminates the plant and forces ripening. This allows the crop to be harvested sooner than if it had ripened naturally. Swathing is an attractive option to many producers since they can harvest swathed canola before wheat. Swathing too early results in green seed, lower oil content, and higher seed moisture. Swathing too late may result in excessive shattering.

Swathing during hot (85 degrees Fahrenheit), dry, and windy weather stops natural chlorophyll clearing due to low seed moisture. Try to swath during the cool evening hours, at night, or early morning to allow the seed to dry at a slower rate. Swathing can be done when there is heavy dew or light drizzle. The draper, belt-style of swather should be used.

The windrow must flow smoothly through the swather without bunching or twisting. Bunching and twisting leads to uneven drying and combining problems as well as increased potential for spoilage in the windrow.

Canola should be swathed just below the pods to reduce the amount of crop passing through the throat. This leaves a maximum amount of stubble on which to lay the windrow and ensure adequate air circulation. The windrow should not be placed on the ground. Many canola producers will use a roller behind the swather to firm up the windrow and reduce the risk of blowing (Photo 102). Set the roller at a height that will slightly force the windrow into the stubble. The stubble acts as an anchor and helps prevent the windrows from moving in the wind.

Field staging for optimum time of swathing

Start inspecting fields approximately 7 to 10 days after flowering ends. Sample five to 10 plants in several spots, examining pods on the main raceme and side branches. Using the seed color change chart (see Figure 8 in color pages), take note of the seed color change percentage on the main raceme. Only seeds that are reddish-brown to brown-black or seeds that have small patches of reddish-brown color (spotting) should be counted as color change or "turned" seed (Photo 103). The seeds in the top one-third should be green, firm, and roll, as opposed to break or crush, when a slight pressure is applied between the forefinger and thumb. The majority of the middle one-third seeds should be turned (Photo 104). Seeds in pods on the bottom one-third of the main raceme mature first. The bottom one-third should be turned and completely reddish-brown or brown-black (Photo 105). This is how seed color change will look at 50 percent.

After assessing the main stem, look at the seed from the pods on the side branches to ensure that they are firm with no translucency. Once you have sampled the main raceme and side branches, estimate the average percent seed color change for that field. Continue inspections every 2 to 3 days to monitor color change until the proper amount of seed color change has been reached. Seed color is more important than the overall field, stubble, and pod color when gauging the optimum time to swath.

Swathing canola too early, at around 10 to 20 percent seed color change, will sacrifice a large proportion of yield and reduce oil content. Many seeds on the side branches may be immature at this stage and these seeds will not fully ripen in the swath. Green seed may become an issue if these seeds make it to the bin.

Hot, windy, and dry conditions following swathing increase the potential for yield loss and reduced oil content due to accelerated dry-down and seed shrinkage. The key to properly curing the crop in a windrow is having adequate seed moisture to naturally clear chlorophyll.

Shattering losses may be high if the decision to swath is made late (beyond 70 to 80 percent seed color change.) If a field at this stage must be swathed, it should be done under damp conditions (after a rain or heavy dew) to limit shattering as much as possible.

Judging when to swath crops with multiple stages of maturity can be tricky. If the field has distinct late and early areas, make the decision to swath based on which areas are likely to contribute the most to yield. If portions of the field are near the point of shattering, swath during the evening hours or when there is high humidity to reduce shatter losses from swathing.

Advantages of swathing canola

- Harvest 1 week earlier than direct cutting.
- Earlier harvest increases opportunities for double cropping.
- Greater flexibility with large acreages.
- Swathing can be performed at many hours of the day.
- Cutting weeds early with the swather improves the cleanliness and dryness of the harvested seed, and it reduces the number of weed seeds that reach maturity and get into the grain.
- A properly swathed, tightly rolled windrow will withstand heavy rain storms and high winds.
- Uneven field maturity makes swathing a desirable option because of timing concerns associated with direct harvesting the crop.

Disadvantages of swathing canola

- Be cautious about swathing canola if the weather forecast is for extremely hot, dry, and windy conditions.
- Swathing at temperatures of 85 degrees Fahrenheit or greater may rapidly dry the crop and result in seed shrinkage.
- Swathing too early may result in lower yield, reduced oil, and greater risk of green seed.
- Swathing too late may result in greater risk of seed shatter.
- Swathing requires additional equipment and a second pass over the field.

- Once the crop is swathed, the seed does not continue filling. Seed swathed before achieving its full complement of oil and protein will not accumulate any more after swathing.
- Swathing equipment may be difficult to acquire or not be readily available.
- Stands of canola that are tall, tangled, or lodged make it difficult to lay down a smooth windrow.
- In heavy crops, the amount of material forced through the throat of the swather can be a problem.
- Light or fluffy windrows can be lifted and blown by wind.

Combining swathed canola

Canola that is swathed is ready to harvest when seed moisture has dropped to 10 percent or below. Under normal conditions, this is about 5 to 10 days after swathing. Most seeds should be mature with little or no green color. A moisture meter is essential to ensure correct harvest moisture and timing. If green seed is present and it is early in the harvest window, wait for more green seed to clear. However, by leaving windrows to reduce green seed count, the risks for prolonged wet weather delays and for yield and quality losses from severe weather are increased. A small percentage of green seeds reduces the grade.

Windrows are best picked up by using draper belts with rubber or synthetic fingers (Photo 106). These types are preferred because their gentler action reduces shattering losses at the header. Aluminum pickup headers are well suited for bunched windrows. Rigid, flex, or draper headers require a crop lifter attachment that is the width of the windrow to lift it into the header. The cutter bar may be covered to prevent or reduce the amount of second-cut stubble entering the combine. Make sure the combine is not cracking seeds or losing too much seed out of the back. See the *General settings for conventional combines* section.

Desiccants

Desiccants are advantageous harvest aids if direct cutting will be used. Desiccants are especially useful where plants are excessively lodged, weed infestations are heavy, or maturity is not uniform. Diquat dibromide (Reglone) and Nufarm Diquat SPC 2 L are available for use as desiccants in the southern Great Plains. For desiccants to be effective, a large spray volume is required (15 plus gallons per acre), a coarse spray droplet is recommended, and ground application is preferred. Use a nonionic surfactant at a rate of ½ to 4 pints per 100 gallons of spray solution (0.06 to 0.5 percent v/v). Some parts of the plant will still remain untouched, even at high water volumes. Coverage is the key to good activity. Sharpen (saflufenacil) is another desiccant used in canola. Apply Sharpen at a rate of 1.0 to 2.0 fluid ounces per acre. Allow 10 days for the best effectiveness.

The recommended stage of growth for applying diquat or Sharpen on canola is 70 to 80 percent seed color change, which is beyond the optimum stage for swathing. The herbicide label for diquat recommends waiting 7 to 10 days to harvest canola following application. Do not wait longer than 14 days for diquat to be effective. It is unlikely that diquat will provide any additional benefit beyond 10 days following application. Waiting for further activity increases the risks of shattering.

Diquat is a contact herbicide that is registered for canola to kill green plant material to facilitate harvest. This means that only the parts of the plant that are contacted by the spray solution will be killed. Desiccation does not necessarily hasten crop maturity; it shuts the plant down quickly and stops it from maturing. If applied prematurely, high green seed count and reduced oil content may occur. There will be no further ripening once the application has been made.

The herbicidal activity of diquat occurs quickly, within minutes of the treated plant's exposure to sunlight, and continues for only a few hours. Applications made in bright sunshine are active as soon as the spray hits the leaf surface and any further spread is immediately stopped. To allow diquat to spread as far as possible before activation, apply under cloudy conditions or in the evening. Plants will have a water-soaked appearance shortly after application as the liquid contents leak from ruptured membranes of plant cells.

Direct Combining

Fields that make good candidates for direct combining are those with heavy crop canopies that are well knitted to prevent shattering from strong winds. The final decision on whether to direct combine must be made before the optimal swathing stage (up to 70 percent seed color change).

Dry down happens quickly in the southern Great Plains because of wind and warm air temperatures (Photo 107). Ideally, canola should be harvested when the average seed moisture is at or below 10 percent and few green pods are visible. However, canola is an indeterminate crop and retains some immature pods and seeds at harvest. Do not bother with allowing smaller immature pods and seed to mature. If the combine is set correctly, these will be blown out of the back. Check the grain in the grain tank to ensure there is little to no green seed; this will give good indication that the combine is set properly. Waiting for smaller seedpods to mature causes larger, higher-yielding seedpods to shatter. Harvesting at slightly higher moisture content (10 to 12 percent) and then drying down in a bin may reduce the risks of pod shatter.

Ripe standing winter canola is easy to thrash. Therefore, open the concaves to reduce grinding of stalks. Ground stalks may increase moisture content of the harvested grain. Allowing more material through keeps the moisture content of the grain lower. Keep an eye on what is coming out of the back of the combine and do not be concerned if a few green pods are observed.

Advantages to direct combining

- Best opportunity to deliver No. 1 quality grain because of reduced green seed potential.
- Generally results in the best yield, protein, and oil content.
- One-pass harvest.
- No swathing equipment or pickup attachments are required.
- Best method for stands of canola that are tall, heavy, laced together, or lodged.
- Avoid the risks of improperly laying, twisting, or bunching the crop in a windrow.
- Decreased risk of rotting from wet weather and poor drying conditions when canola is lying in a windrow.
- Easiest method to harvest thick, productive crops.

Disadvantages to direct combining

- Must harvest when crop is ready. Do not wait several days until wheat harvest is finished.
- Bad weather or wet fields at maturity could delay harvest, allowing shattering to begin.
- Shattering due to hail, high wind, or severe storms may be worse if the crop is standing.
- The longer the mature crop stands in the field, the greater potential for shatter losses. Rain on a standing crop increases the potential for shatter losses as it reduces the integrity of the seed pods.

General harvest guidelines and settings for conventional combines

- Refer to operator's manual for adjustment settings for canola or rapeseed. Most settings in operator's manuals are based on swathed canola. Further adjustment is usually needed.
- Ground speed is slower than wheat harvest.
- Harvest canola immediately below the seedpods to avoid excessive trash and green stems moving through the combine.
- The reel should be set high and as far back over the grain table as possible.
- Reel speed should be the same as ground speed.
- Cylinder speed should be slow (450 to 650 rpm), about one-half to two-thirds that for wheat. Cracked seed indicates excessive speed.
- Set concave clearances at ¾ inch in the front and ⅛ to ¼ inch in the rear. Remember, canola is easy to thresh. Grinding the stems increases seed moisture.
- Fan speed is similar to wheat (400 to 600 rpm). Shaking the seed out of the chaff is better than trying to blow the chaff out the combine.
- Set the top sieve/chaffer at ¼ to ⅜ inch for proper separation.
- Set the lower cleaning sieve at ⅛ to ¼ inch.
- For rotary combines, use settings from the operator's manual. Most settings can be adjusted from the cab.
- Avoid combining during hot, dry, and windy days if the pods are brittle. Cooler mornings and evenings with a bit of dew are preferable, but this can present a challenge if the stems are somewhat green and wet. Depending on the seed moisture level, harvesting in damp conditions may require additional conditioning for safe storage.
- Canola seed can be difficult to see once it falls to the ground. To determine potential combine loss, it is better to place a small box on the ground ahead of the combine and then look to see what is inside after the combine passes over it.
- Check around the combine for places where the seed may be falling out and fill those cracks with duct tape, caulking, or grease.
- Work around low spots of late maturity and high weed biomass. These slow harvesting, and any green plant material in the sample increases spoilage. Harvest these areas later.
- About 130 to 150 seeds per square foot equals 1 bushel per acre (50 lb) of loss.

Pushing

Pushing is another optional harvest aid, but it is relatively unused in the southern Great Plains. A pusher is mounted on the three-point hitch of a bidirectional tractor or the front of a tractor and it is driven through canola at a relatively high speed to force lodging (Photo 108). Mounting a pusher on front loader brackets has not been successful because the unit is too wide and heavy and the pusher must be kept level during this high-speed operation. Vertical sickles are located at both ends of the pusher and directly in front of the tractor tires. These are designed to make a clean cut between passes and reduce the amount of canola crushed to the ground by the tires. Pods cut off by these sickles are lost.

By pushing the canola crop over, it is less susceptible to blowing in the wind and shatter losses. While the plant is not lodged completely on the ground, the pod layer is much denser, which helps prevent pod movement and reduce plant-to-plant contact in high wind. The goal is to curve the stalks over, but not kink them or rip them out of the ground. Since the plant is intact, it will ripen naturally.

Although experience with pushing is limited, it may work better in some situations than in others. Pushers work best in fields with high production potential and few or no terraces. Pushing works better in taller, even crops. Shorter, thin crops simply stand back up, minus a few pods, after the pusher has gone through the field. The optimum speed for pushing may vary depending on crop size and density.

After the crop matures, it is direct combined. The combine must travel in the opposite direction of the pusher and the header should match the width of the pusher. The combine header must operate closer to the ground than for standing canola. Harvesting is slower because more stalk material enters the combine. Dry down of the seed is much slower than swathing or desiccating the crop.

Storage

Successful canola storage requires cool, dry conditions. Storing canola in the Great Plains requires aeration. Potential risks of improper storage include heating and spontaneous combustion, insect infestation, clumping due to molding, and free fatty acid development.

Ripe canola varies in moisture and oil content. Moisture content and seed temperature when placed in storage determine the amount of drying and cooling necessary to prevent spoilage. Canola undergoes a period of extended respiration or "sweat," producing heat and moisture for 6 to 8 weeks after harvest. Aeration and intensive monitoring are required to prevent quality loss.

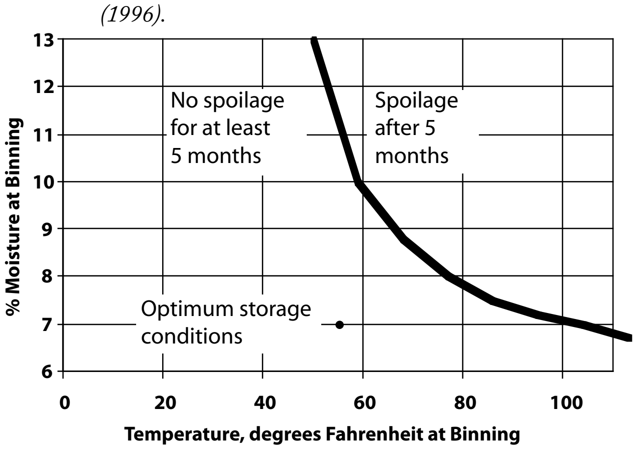
Optimum Storage Conditions

Canola seed may be conditioned using aeration to reduce moisture and temperature to safe levels for long-term storage. Figure 9 shows the moisture content and temperature relationship for safe storage up to 5 months. Seed stored at conditions below and to the left of the curve showed no loss of quality for 5 months. While optimum storage conditions are 55 degrees Fahrenheit and 7 percent seed moisture, every reduction of 10 degrees Fahrenheit below 77 degrees Fahrenheit and 1 percent seed moisture below 9 percent will double the storage life. Storage below 6 percent seed moisture may result in seed damage during handling. The higher the storage temperature, the lower the moisture content must be for successful storage.

Cleaning Canola Seed

Broken seeds, pods, dirt, and other debris (also known as "dockage") make aeration more difficult by reducing airflow through the seed and can affect seed moisture content. Surface debris in storage also attracts insects. Insect development and activity cause excess heat and moisture, which encourage mold growth. Seed should be cleaned to less than 2.5 percent foreign material before storage. Canola can be cleaned by a number of different methods including air aspiration, indent cylinder cleaning, sieve screening, or a combination of these methods.

Figure 9. *Safe and spoilage conditions for canola adapted from Mills (1996).*



Moisture, Oil Content, and Storability

Equilibrium relative humidity is the point at which there is no exchange of moisture between the seed and the surrounding air. Mold begins to grow when the equilibrium relative humidity is above 60 percent. Temperature and seed oil content determine the equilibrium relative humidity of the stored canola. Canola varieties appropriate for the Great Plains average 40 percent oil content. Table 20 shows the equilibrium relative humidity for canola with 40 percent seed oil content at various temperatures and seed moistures. The shaded area shows the optimum seed conditions to prevent mold growth and seed handling damage. For example, a seed temperature of 80 degrees Fahrenheit must have a moisture content of 7.6 percent or less to have an equilibrium relative humidity less than 60 percent.

Higher oil contents require lower seed moisture levels for successful storage. For example, at 60 degrees Fahrenheit, canola with 50 percent oil content can be safely stored at 6.5 percent moisture content or less as compared to 8.4 percent moisture content for seed with 40 percent oil content as shown in Table 20. As the oil content increases, the safe moisture level decreases.

Lower seed moisture and lower oil content allow storage at higher temperatures; however, excessive free fatty acid may form when temperatures remain higher than 77 degrees Fahrenheit for more than a year. Free fatty acid content must stay below 1.5 percent to ensure marketability. Freshly harvested canola seed typically has free fatty acid levels less than 0.5 percent.

Aeration for Cooling and Drying

Aeration systems that have been properly designed to provide adequate uniform airflow provide a cost-effective way to cool and store canola. Round steel grain bins are well suited for storing canola. Because canola seed is much smaller than wheat and other cereal grain, fine mesh screen (such as window screen) must be placed over the floor perforations to prevent seed leaking through the perforations. Bins should be equipped with temperature and relative humidity monitoring equipment. OSU Fact Sheet BAE-1101 *Aeration and Cooling of Stored Grain* gives aeration and grain cooling information for Oklahoma.

Airflow rates for temperature management of canola are 0.08 to 0.15 cubic feet per minute per bushel. At 0.08 cubic feet per minute per bushel, about 150 to 200 hours are needed to change the temperature of the entire bin 20 degrees Fahrenheit (i.e. from 80 degrees Fahrenheit to 60 degrees Fahrenheit or from 60 degrees Fahrenheit to

40 degrees Fahrenheit). At 0.15 cubic feet per minute per bushel, the time is reduced to less than 100 hours. Aeration fans should be started as soon as the seed covers the floor and run continuously until the seed temperature throughout the bin is near the average outside temperature. After the initial cooling period, the fans should operate whenever the outside air temperature is at least 5 to 10 degrees Fahrenheit below the seed temperature and the relative humidity is less than 95 percent.

Bin aeration can be used to dry the seed to the proper storage moisture content, but increased airflow rates are required. Typical airflow rates for drying range from 0.4 to 2 cubic feet per minute per bushel. These higher airflow rates increase the static air pressure. Table 21 shows the static pressure for canola with fan airflow rates of 0.75 and 1.0 cfm per bushel at several grain depths. OSU Fact Sheets BAE-1102 *Aeration Systems for Flat-Bottom Round Bins*, and BAE-1103 *Aeration Systems for Cone-Bottom Round Bins,* provide aeration system design information. The static pressure of canola is two to three times that of wheat. If an existing aeration system designed for wheat is used for canola, check the velocity and pressure ratings of the system to ensure adequate airflow.

When drying canola, the fans should operate continuously until the desired moisture level is achieved, even if the relative humidity occasionally spikes. This ensures the drying front continues to move through the stored seed. The moisture redistributes through the seed and spoilage should not occur.

Insect and Mite Control

Insects can cause extensive damage in stored bulk products. Good management practices help prevent this damage. Always clean bins thoroughly before grain storage.

The surface of stored canola is the primary area of attack. Insects are attracted by trash, broken seeds, and fine material that accumulate on the surface. Cleaning seed before storage reduces infestations.

OSU Fact Sheet F-7180 *Stored Grain Management in Oklahoma* provides detailed information about the identification and prevention of different pests commonly found in products stored in Oklahoma.

Table 21. *Static pressure of canola in storage.*

Static Pressure	Airflow Rate (cfm/bushel)	
inches of water and psi	**0.75**	**1.0**
	Canola Depth	
6 inches (2.6 psi)	13 ft.	11 ft.
7 inches (3.0 psi)	14 ft.	12 ft.
8 inches (3.5 psi)	15 ft.	13 ft.

Grain-handling Equipment

Equipment used for cereal crop production may be used to handle canola. Plug holes in truck beds, grain carts, and combines with tape or caulk to prevent seed loss.

Canola has an angle of repose of 22 degrees, compared to 28 degrees for wheat. This causes seed to flow more readily and may cause additional force on the sides of carts and bins. Level the grain surface on binning or transfer.

Operate augers at full capacity to prevent seed flow back. Belt conveyors should be enclosed in a trough to prevent seed from dropping off. Damage to seed due to handling is minimal above 7 percent seed moisture content.

OSU Fact Sheet CR-1726 *Grain Bin Entrapment: What if it Happens to you?* provides safety information for working with grain bins and emergency procedures in case of accidents.

Table 20. *Equivalent relative humidity and temperature influence on seed moisture content. (NDSU 2005).*

Equivalent Relative Humidity, percent	Temperature, °F (40 percent seed oil content)						
	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

Budgets

Table 22 includes four sets of returns and cost estimates (enterprise budgets) for wheat in a rotation with canola, Roundup Ready canola in a rotation with wheat, conventional canola in a rotation with wheat, and continuous wheat. The purpose is to compare the returns from wheat-wheat-canola rotations to a continuous wheat rotation return. The listed set and quantity of variable inputs is based on estimates provided by wheat and canola production experts. The budgets are designed to reflect conventional tillage for an average acre in a representative Oklahoma field. Enterprise budget software is available to develop budgets customized for a specific field or farm. Oklahoma budgets are available at *www.agecon.okstate.edu/budgets*. Budgets for Kansas are available online at *www.agmanager.info* and for Texas at *agecoext.tamu.edu/resources/crop-livestock-budgets/budgets-by-extension-district/*.

Dryland wheat yields in the southern Great Plains vary considerably across years and across fields within years. The Oklahoma state average research plot yield per harvested acre was 24 bushels in 2006, 28 bushels in 2007, and 37 bushels in 2008. In 2009, USDA began reported canola acres and yields. Producer-reported canola yields range from 73 percent to 100 percent of Oklahoma state average wheat yields. On average, canola bushel-per-acre yields at the state level were 84 percent of state average wheat yields.

Wheat is known to yield more following canola than continuous wheat. Results from a recent study (Bushong et al.) show that wheat following canola yields 10 to 15 percent higher than continuous wheat. However, given a 3-year rotation, data are unavailable to measure the persistence of this effect on second-year wheat following canola.

In the attached budgets, an average increase in wheat following canola of 7.5 percent is assumed. The example budgets include a wheat yield of 40 bushels per acre for continuous wheat and 43 bushels per acre (a 7.5 percent increase) for wheat grown in a canola-wheat-wheat rotation. The budgeted yield of 1,900 pounds (38 bushels) per acre for canola is approximately 85 percent of the wheat yield (when yields of both wheat and canola are measured in bushels per acre).

The costs of nitrogen, harvest, and hauling are adjusted with yield. Costs for other inputs do not vary with yield. The expected nitrogen requirement for wheat is computed by multiplying the expected yield in bushels per acre by 2 pounds of nitrogen per bushel and subtracting the assumed level of carryover soil nitrogen of 15 pounds per acre. For an expected yield of 40 bushels per acre, the required level of nitrogen, in addition to the expected carryover and that applied in 65 pounds per acre of diammonium phosphate (DAP) (18-46-0), is estimated to be 56 pounds per acre [(40 bushels per acre × 2 pounds per bushel) – (50 pounds per acre × 0.18) – (15 pounds per acre carryover)]. This requirement can be met with 65 pounds per acre of anhydrous ammonia (82-0-0) and 25 pounds of urea.

For an expected yield of 1,900 pounds per acre of canola and an expected requirement of 0.05 pounds of nitrogen per pound of canola, a total of 95 pounds per acre of actual nitrogen is needed. Given a carryover of 15 pounds, one-third of the remaining requirement is applied preplant in the form of anhydrous ammonia (82-0-0) or 39 pounds of 82-0-0. The remainder is topdressed using 50 pounds of DAP (18-46-0) and 117 pounds of urea (46-0-0). For winter canola, it is recommended that only one-third of the nitrogen be applied preplant with the remaining two-thirds applied as a topdress in February.

The cost and availability of crop insurance varies by county, crop, production history, and level of coverage. Producers are encouraged to contact their local crop insurance agent to determine costs for specific levels of coverage.

Input prices differ across regions, months, and dealers. In some situations, differences in prices reflect differences in services, quality, and timeliness. Most prices are negotiable and many producers negotiate with a good understanding of expected differences in services, quality, and timeliness that are not readily apparent in posted prices.

For the budgets reported in the table, machinery fixed costs, and costs for labor, land, management, overhead, and risk are not included. These excluded costs are assumed to be similar for wheat and canola grown to produce only grain. An individual producer, to more nearly represent a specific situation, may adjust the input and production quantities and prices reported in the table.

Oklahoma producers who are interested in more comprehensive economic analysis for their specific farms are encouraged to take advantage of the Intensive Financial Management and Planning Support (IFMAPS) program available through the Oklahoma Cooperative Extension Service. Producers may contact their local county extension office for more information.

Table 22. *Budgets for continuous wheat and for a canola-wheat-wheat rotation.*

			Production System							
			Continuous Wheat		Wheat in Canola-Wheat-Wheat Rotation		Roundup Ready Canola in Canola-Wheat-Wheat Rotation		Conventional Canola in Canola-Wheat-Wheat Rotation	
Item	Unit of Measure	Price per unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production										
Wheat	bu	$4.70	40	188.00	45	211.50				
Canola	lbs	$0.13					1,900	254.60	1,900	254.60
Gross Returns	acre			188.00		211.50		254.60		254.60
"Cash" Costs										
Wheat Seed	bu	$12.00	1	12.00	1	12.00				
Canola Seed (RR + tech fee + treatment)	lbs	$5.50					5	27.50		
Canola (Conventional, treated)	lbs	$3.00							5	15.00
Anhydrous Ammonia (82-0-0)	lbs	$0.21	65	13.33	70	14.35	39	8.00	39	8.00
Fertilizer Application	acre	$12.00	1	12.00	1	12.00	1	12.00	1	12.00
Urea (46-0--0)	lbs	$0.17	25	4.31	38	6.56	117	20.18	117	20.18
DAP (18-46-0)	lbs	$0.18					50	9.03	50	9.03
Fertilizer Application	acre	$4.00	1	4.00	1	4.00	2	8.00	2	8.00
Herbicide (broadleaf)	acre	$2.70	1	2.70	1	2.70				
Herbicide (grass)	acre	$18.00	1	18.00	1	18.00				
Herbicide (e.g. Select)	oz	$0.84							9	7.56
Herbicide (e.g. Assure II)	oz	$0.98							8	7.84
Herbicide Additive (Crop Oil Concentrate)	acre	$1.25							2	2.50
Herbicide (glyphosate)	oz	$0.20					44	8.80		
Herbicide Additive (ams)	units	$0.29					4	1.16		
Herbicide Application	acre	$5.00	2	10.00	2	10.00	3	15.00	3	15.00
Insecticide (e.g. dimethoate)	pint	$5.91	0.75	4.43	0.75	4.43				
Insecticide (e.g. Warrior) Fall (1 of 3 yrs)	oz	$3.67					0.33	1.21	0.33	1.21
Insecticide (e.g. Warrior) Spring	oz	$3.67					3	11.01	3	11.01
Foliar Fungicide (1 of 3 years)	acre	$16.20	0.33	5.35	0.33	5.35				
Aerial Pesticide Application	acre	$5.00	1.33	6.65	1.33	6.65	1.33	6.65	1.33	6.65
Wheat Crop Insurance	acre	$8.00	1	8.00	1	8.00				
Canola Crop Insurance	acre	$16.00					1	16.00	1	16.00
Fuel	gallon	$2.50	2.8	7.00	2.8	7.00	4.92	12.30	4.92	12.30
Lube	acre			2.00		2.00		2.00		2.00
Repair	acre			7.12		7.12		7.12		7.12
Annual Operating Capital	$	$0.05	116.95	1.95	120.22	2.00	153.45	2.56	158.89	2.61
Wheat Custom Harvest & Haul										
Base Charge	acre	$20.00	1	20.00	1	20.00				
Excess for > 20 bu/a	bu	$0.18	20	3.60	25	4.50				
Hauling	bu	$0.20	40	8.00	45	9.00				
Canola Custom Harvest & Haul										
Swathing	acre	$15.00					1	15.00	1	15.00
Combining	acre	$21.00					1	21.00	1	21.00
Excess for > 20 bu/a	bu	$0.21					20	4.20	20	4.20
Hauling	bu	$0.23					40	9.20	40	9.20
Total "Cash" Costs	acre			$151		$156		$205		$210
Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management	acre			$37		$56		$50		$45

Crop Insurance

Canola can be insured in the county for which a premium rate is provided by the actuarial document in which the insured has a share. Unless allowed by special provisions, canola cannot be insured where it is interplanted with another crop or planted into an established grass or legume. If canola is grazed, it is uninsurable. Crops with similar disease profiles such as crambe, chickpeas, dry beans, mustard, rapeseed, or sunflowers that have been planted in the previous year will disqualify the field for canola insurance. Continuous canola cannot be insured. Broadcast seeding of canola is only insurable if it is mechanically incorporated into the soil and after it is inspected for an adequate stand by the insurance provider.

There are currently 15 insurance program counties in Oklahoma (Alfalfa, Blaine, Caddo, Canadian, Comanche, Cotton, Custer, Dewey, Garfield, Grant, Kingfisher, Logan, Major, Noble, and Woods), five in Kansas (Barber, Gray, Harper, Kingman, and Sumner) and two in Texas (Moore and Wichita). All other counties in Oklahoma, Kansas, and Texas can be insured by written agreement. One actuarial policy provides the option of three plans:

- Yield Protection: Insurance coverage only providing protection against a production loss.
- Revenue Protection: Insurance coverage providing protection against loss of revenue due to a production loss, price decline or increase, or a combination of both.
- Revenue Protection with Harvest Price Exclusion: Insurance coverage providing protection only against loss of revenue due to a production loss, price decline, or a combination of both.

A written agreement only provides yield protection. Written agreements can be obtained by first-time canola producers using similar crop support documentation. Winter wheat, barley, and oats qualify as similar crops, but only one similar crop can be used. Production for 3 years of a similar crop must be demonstrated.

The price election for winter canola uses the projected price (base price) that is based on the preharvest average daily settlement price discovery period of July 15 to August 14 for the harvest year's future contract on the InterContinental Exchange. For revenue plans, a harvest price is based on the harvest year's average daily settlement price for the harvest price discovery period of June 1 to June 30 on the InterContinental Exchange.

To receive all benefits of the policy, including coverage for replanting, canola must be planted within the planting window of the given state. The planting window for insurance in Gray County and far western Kansas is August 25 to September 25. For Barber, Harper, and Sumner counties in Kansas it is September 10 to October 10. For Kingman and all other counties in Kansas it is September 1 to September 30. In Oklahoma, the planting window is September 10 to October 10. In Texas, the planting window ranges from September 1 to September 15 in the northern Panhandle to October 1 to October 30 in central areas of the state. There is a late planting period of 5 days following the final planting date. The guarantee for each acre will be reduced 3 percent for each day planted after the final planting date. Visit *www.rma.usda.gov* for a current commodity insurance information.

Table 23. *Canola weed control suggestions. Read and follow all label directions before product use.*

Trade Name, Formulation, and Application Rate	Active Ingredient(s), Similar Products, and MOA Group	Application Timing(s), EPP-early preplant, PPI-preplant incorporated, PRE-preemergence, or POST-postemergence	Special Instructions and Remarks
Assure II/Targa 0.88 lb ai per gallon **Postemergence:** 5 to 12 fl oz/a	**Active Ingredients:** Quizalofop **Similar Products:** MOA: 1	**POST.** Apply after crop and weed emergence but before grasses tiller. **Will NOT control sedges or broadleaf weeds**	**Do not** apply Assure II within 60 days of harvest. **Do not** apply more than 18 oz/a per season. **Do not** graze livestock in treated areas or feed forage, hay, or straw from treated areas to livestock. **Do not** cultivate within 7 days after application. Optimum timing for cultivation is 7 to 14 days after application of Assure II. Applications must always include a crop oil concentrate or non-ionic surfactant.
Poast 1.5 lb ai per gallon **Postemergence:** 0.5 to 2.5 pt/a	**Active Ingredient:** Sethoxydim **Similar Products:** None. Rates may vary due to formulation. **MOA: 1**	**POST.** Apply POST to actively growing grass weeds within size limits on label. Apply to grasses after crop and weed emergence. Annual grasses that emerge after application will not be controlled. Apply to actively growing grasses at recommended weed heights. **Will NOT control sedges or broadleaf weeds.**	**Do not** harvest canola for at least 60 days after application. **Do not** apply more than 2.5 pt/a per application. **Do not** exceed 5 pt/a in a season. **Do not** graze or feed forage, hay, or straw.
Glyphosate Multiple formulations **Early preplant:** 0.75 lb acid equivalent/a **Postemergence:** 0.75 lb acid equivalent/a	**Active Ingredient:** Glyphosate **Similar Products:** Many. Rates and required adjuvants may vary due to formulation and manufacturer. See appropriate label. **MOA: 9**	**EPP BURNDOWN.** Apply before planting the crop to control existing weeds. Will not control weeds that have not emerged. **PRE.** Apply after planting but before crop emergence. Will not control weeds that have not emerged. **POST.** Apply POST only in **Roundup Ready canola cultivars and hybrids. Single Application.** One postemergence application of 0.75 lb acid equivalent/a can be applied from emergence to before bolting. **Sequential Applications.** Two sequential applications of 0.75 lb acid equivalent/a can be applied from emergence to before bolting.	**Apply POST only in Roundup Ready canola cultivars.** Do not apply more than 1.5 lb acid equivalent/a of glyphosate during a growing season; **do not** apply more than 1.5 lb acid equivalent/a during EPP burndown or preplant applications and no more than 0.75 lb acid equivalent/a over the top of Roundup Ready canola from emergence to the bolting stage. Applications made during bolting or flowering may result in crop injury and yield loss. No more than two postemergence applications can be made to Roundup Ready canola from emergence to the bolting stage. Allow at least 60 days between last glyphosate application and canola harvest. Will not control glyphosate resistant weed biotypes.
Select Max 0.97 lb ai per gallon **Postemergence**: 9 to 12 fl oz/a	**Active Ingredient:** Clethodim **Similar Products:** Arrow Envoy Volunteer Section Rates may vary due to formulation. **MOA: 1**	**POST.** Apply to grasses after crop and weed emergence. Annual grasses that emerge after application will not be controlled. Apply to actively growing grasses at recommended weed heights. **Will NOT control sedges or broadleaf weeds.** The recommended rate for control of cheat, ryegrass, rye, wild oats, and other winter annual grasses common in the southern Great Plains canola fields is 9 to 12 fl oz/a.	**Do not** apply more than 12 fl oz/a per application and no more than 12 fl oz/a per season. **Do not** allow Select to drift onto wheat or other grass crops as severe crop injury will occur. **Do not** apply after canola has begun bolting. Apply with 0.25% v/v non-ionic surfactant (NIS). Including liquid fertilizer with the application is **NOT** recommended. **Do not** apply under conditions of drought stress. **Do not** graze treated fields or feed treated forage or hay. **Do not** apply within 70 days of harvest. **Do not** plant any crop for 30 days after application unless registered for use in that crop.

Table 23. *Continued on page 38*

Table 23. *Canola weed control suggestions.* *Continued from page 37*

Trade Name, Formulation, and Application Rate	Active Ingredient(s), Similar Products, and MOA Group	Application Timing(s), EPP-early preplant, PPI-preplant incorporated, PRE-preemergence, or POST-postemergence	Special Instructions and Remarks
Sonalan HFP 3 lb ai per gallon **Preplant incorporated:** 1.5 pt/a - Coarse Soil 2 pt/a - Medium 2.5 pt/a - Fine Soil	**Active Ingredients:** Ethalfluralin **Similar Products:** Sonalan 10G **MOA: 3**	**PPI.** Apply to soil surface before planting and incorporate into the upper 2 to 3 inches of soil. Incorporation should occur within 48 hours of application. For best performance, incorporate with two passes in different directions.	**Do not** apply to soils that are wet or are subject to prolonged periods of flooding as poor weed control may result. **Do not** graze or harvest for livestock forage.
Stinger 3 lb ai per gallon **Postemergence:** 4 to 8 fl oz/a	**Active Ingredient:** Clopyralid **Similar Products:** None **MOA: 4**	**POST.** Apply postemergence when canola is in the 2- to 6-leaf stage. Apply by ground rig in 10 to 20 gallons of water carrier or by air in a minimum of 10 gallons per acre water carrier. For control of broadleaf weeds only.	**Do not** exceed 0.25 lb ai/a of clopyralid per crop year. **Do not** move livestock from treated grazing areas onto sensitive broadleaf crop areas without first allowing 7 days of grazing on an untreated pasture. Use of a spray adjuvant is not necessary but may increase control of some weeds. **Do not** apply within 50 days of harvest. **Do not** make more than one application/crop/year.
Treflan HFP 4 lb ai per gallon **Preplant incorporated:** 1 pt/a - Coarse Soil 1.5 pt/a - Medium 2 pt/a - Fine Soil	**Active Ingredients:** Trifluralin **Similar Products:** Trifluralin HF Trust 4EC **MOA: 3**	**PPI.** Apply to soil surface before planting and incorporate into the upper 2 to 3 inches of soil. Incorporation should occur within 24 hours of application. For best performance, incorporate with two passes in different directions.	**If applying through irrigation system:** Apply only through continuously moving center pivot, lateral move end tow, solid set, or hand move irrigation systems. **Refer** to label for additional chemigation instructions. **Do not** apply to soils that are wet or are subject to prolonged periods of flooding as poor weed control may result. **Do not** graze or harvest for livestock forage.

Table 24. *Management of insect and mite pests in canola. Read and follow all label directions before product use. Labels and rates may change, consult university fact sheets for current Information.*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
Aphids	***Cabbage aphid:*** Small blue-gray aphid with short cornicles, and is usually covered with a powdery wax secretion. ***Green peach aphid:*** Pale green to yellow with long cornicles and three dark lines on abdomen. ***Turnip aphid:*** Pale gray-green with short, swollen 1/16-inch cornicles. Winged adults can be recognized by presence of transverse dark bands on last two abdominal segments. ***Damage:*** High populations can cause stunting and discoloration of leaves. Feeding by cabbage aphid can stop terminal growth and reduce yield. ***Threshold:*** Treat rosette stage plants when aphids exceed 100 to 200 per plant. Treat bud and early bloom stage when infested plants (racemes) exceed 15 percent.	**Planting Time**		
		Helix XTra (4A) (thiamethoxam)	23 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except winter wheat.
		Prosper FX (4A) (clothianidin)	21.3 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except corn.
		Post-Plant		
		Azadirachtin (20B)	1 pt	No PHI for harvest. (Other names: Azadirect, Ecozin.)
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Carbine 50 WG (flonicamid)	2.8 oz	7-day PHI. Apply before aphids reach high levels. (Beleaf is also registered for rapeseed.)
		Karate/Warrior II (lambda-cyhalorthrin)	1.92 fl oz	7-day PHI for harvest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing.
		Transform WG (4C0 (Sulfoxaflor)	0.5 to 0.75 oz	7-day PHI for harvest. Apply after petal fall only.
		Planting: Research data indicate that aphids are a consistent pest of winter canola in fall and winter. The use of seed treatments is highly recommended for early season management of aphids. Additional foliar insecticide applications may be necessary for late-season control. ***Post-Plant:*** Spray in evening during bloom to avoid killing honeybees. Notify beekeepers before spraying if possible.		
Army cutworm	Gray striped caterpillar that curls up into a tight "C" when disturbed. Observed from January through March. ***Damage:*** Cuts plants at soil line and clips opened leaves, can kill plants if it enters the crown. ***Threshold:*** One to two per foot of row.	Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96to 1.92 fl oz	7-day PHI for harvest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Lumiderm (28) (cyantraniliprole)	3.7 to 24.6 fl oz/cwt seed	Seed treatment
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing.

Table 24. *Continued on page 40*

Table 24. *Management of insect and mite pests in canola.* *Continued from page 39*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
Beet armyworm	Green caterpillar, darker above with a white stripe along the side of the body and a small black spot above the second pair of true legs, three pairs of true (thoracic legs) and four pairs of abdominal prolegs. ***Damage:*** Caterpillars thin fall stands and chew conspicuous, irregular-shaped holes in leaves. ***Threshold:*** At seedling stage, treat when scouting indicates one or more per foot of row. Treat when defoliation becomes severe, and larvae are present.	Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		B. thuringiensis (11B1,2)	Apply per label	No PHI for harvest. (Other names: Dipel, Javelin, Leipnox, Xentari.)
		Battalion 0.2 EC	5.8 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for harvest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	1.92 to 3.84 fl oz	7-day PHI for harvest or grazing.
Cabbage looper	Green caterpillar, with a thin white line along each side of the body, three pairs of thoracic legs and three pairs of abdominal prolegs. ***Damage:*** Caterpillars chew conspicuous, irregular-shaped holes in leaves. ***Threshold:*** Treat when defoliation becomes severe, and larvae are present.	Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		B. thuringiensis (11B1, 2)	Apply per label	No PHI for harvest. (Other names: Dipel, Javelin, Leipnox, Xentari.)
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for harvest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing.
Diamondback moth	Adult moths are light grayish-brown with a white diamond-shaped marking along back when wings are folded. Larvae are slightly tapered at each end and pale green in color. Larvae wriggle rapidly when disturbed. ***Damage:*** Larvae feed on all plant parts, preferring the undersides of older leaves. ***Threshold:*** Recommended threshold is two to three larvae per foot of row at seedling stage.	Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		B. thuringiensis (11B1, 2)	Apply per label	No PHI for harvest. (Other names: Dipel, Javelin, Leipnox, Xentari.)
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Coragen (28) chlorantraniliprole	3.5 to 5.0 fl oz	1-day PHI for harvest. Do not make applications less than 5 days apart
		Exirel (28) (cyantraniliprole)	7 to 13.5 fl oz	7-day PHI for harvest. Label recommends using an adjuvant.
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing.

Table 24. *Continued on page 41*

Table 24. *Management of insect and mite pests in canola. Continued from page 40*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
False chinch bug	Adults are ⅛ inch long, dirty gray, with brown or black markings, and piercing mouthparts. ***Damage:*** Feed in groups. Large numbers may cause wilting of heads or stunting of plants. ***Threshold:*** **If swarming aggressively**, treat when 20 to 30 per plant at flowering or 40 to 50 per plant at early pod set. ***Flowering:*** Treat when there is an average of five to 10 per raceme. ***Early seedpod:*** Treat when there is an average of 10 to 20 per raceme.	Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing.
Flea beetle	Shiny black beetle about 1⁄16 inch long that jumps when disturbed. ***Damage:*** Early spring. Feeding damage results in plant tissue that is scraped from leaf and/or small holes chewed in leaves. Can cause delayed development in cool growing conditions. ***Threshold:*** No threshold has been established.	**Planting Time**		
		Helix XTra (4A)	23 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except winter wheat.
		Prosper FX (4A)	21.3 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except corn.
		Post-Plant		
		Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		Battalion 0.2 EC	5.8 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	1.92 to 3.84 fl oz	7-day PHI for harvest or grazing.
Harlequin bug	Black, shield-shaped, with orange, red, and yellow markings. Measures ⅜ inch long. Eggs barrel shaped and laid in clusters. ***Damage:*** Adults and nymphs pierce stalks and leaves with sucking mouthparts. ***Threshold:*** No threshold has been established.	Azadirachtin (20B	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.

Table 24. *Continued on page 42*

Table 24. *Management of insect and mite pests in canola.* *Continued from page 41*

Pest	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
Grasshopper	1 to 2 inches, outer wings leathery, inner wings clear or colored. Enlarged hind legs designed for jumping. ***Damage:*** Chew leaves. Leaves may have ragged edges or leaf blade may be completely chewed. Small plants may be killed. ***Threshold:*** 15 to 20 per square yard. If nymph populations exceed threshold in field borders (25 to 40 per square yard), treat before they move into canola.	Battalion 0.2 EC	5.8 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	1.92 to 3.84 fl oz	7-day PHI for harvest or grazing.
Lygus bug	Several species exist. Generally oval and about ¼ inch long, brown with some yellow or reddish markings. ***Damage:*** Feed on developing leaves, buds, flowers, and seeds. ***Threshold:*** North Dakota thresholds are 15 per 10 sweeps before petal fall, and 20 per 10 sweeps after petal fall.	Azadirachtin (20B)	Apply per label	No PHI for harvest. (Other names: Aza-direct, Ecozin.)
		Battalion 0.2 EC	5.8 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Brigade 2EC (3) (bifenthrin)	2.1 to 2.6 fl oz	35-day PHI for harvest. (Other names: Annex, Bifenture, Discipline, Empower, Fanfare, Sniper.)
		Karate/Warrior II (lambda-cyhalorthrin)	0.96 to 1.92 fl oz	7-day PHI for havest or grazing. (Other names: Grizzly Z, Lambda Cy, Silencer, Tiaga.)
		Mustang MAX (3) (zeta-cypermethrin)	4 fl oz	7-day PHI for harvest. Do not make applications less than 7 days apart.
		Proaxis 0.5 CS (3) (gamma-cyhalothrin)	1.92 to 3.84 fl oz	7-day PHI for harvest or grazing.
White grub	Large, "C" shaped grub with a white body and a brown head. ***Damage:*** Grubs feed on roots of seedling plants. Damage potential is dependent on planting date and speed of growth of the plant. ***Threshold:*** Seed treatments are registered for protection against early season damage. Treat if field history indicates a problem.	**Planting Time**		
		Helix XTra (4A)	23 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except winter wheat.
		Prosper FX (4A)	21.3 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except corn.
		Do not use treated seed for feed, food, or oil purposes.		
Wireworm	Hard-shelled, smooth, cylindrical, yellowish to brown worms. 2 to 6 year life cycle. ***Damage:*** Feed on seed or seedlings, causing stand loss. Common in sandier soils ***Threshold:*** Seed treatments are registered for protection against early season damage. Treat if field history indicates a problem.	**Planting Time**		
		Helix XTtra (4A)	23 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except winter wheat.
		Prosper FX (4A)	21.3 fl oz/cwt seed	30-day postharvest waiting period for planting all crops except corn.
		Do not use treated seed for feed, food, or oil purposes.		

** Group numbers in parentheses (#) after the insecticide name are used to designate the mode of action of the insecticide according to the classification system developed by the Insecticide Resistance Action Committee, (IRAC) in 2005. It is intended to help in the selection of insecticides for preventative resistance management. If you make multiple applications for a specific pest during a growing season, simply select a registered insecticide with a different number for each application. To further delay resistance from developing, integrate other control methods into your pest management programs.*

Disease Photos *(Continued, see page 23 – 24)*

Photo 65. *Powdery mildew.*

Photo 66. *Black rot on leaf.*

Photo 67. *Black rot on plant.*

Photo 68. *Damping off.*

Photo 69. *Aster yellows.*

Insect Pest Identification and Control Photos

(see page 25 for more information)

Photo 70. *Green peach aphid.*

Photo 71. *Turnip aphid.*

Insect Pest Identification and Control Photos

(Continued, see pages 25 – 26)

Photo 72. *Cabbage aphid.*

Photo 73. *Aphids on canola.*

Photo 74. *Army cutworm.*

Photo 75. *Army cutworm damage.*

Photo 76. *Diamondback moth larva.*

Photo 77. *Diamondback moth larvae feeding damage.*

Photo 78. *Diamondback moth adult.*

Photo 79. *Flea beetle.*

Insect Pest Identification and Control Photos

(Continued, see pages 26 – 27)

Photo 80. *Cabbage root maggot.*

Photo 81. *False chinch bug.*

Photo 82. *False chinch bug on raceme.*

Photo 83. *Fall armyworm.*

Photo 84. *Cabbage seedpod weevil adult.*

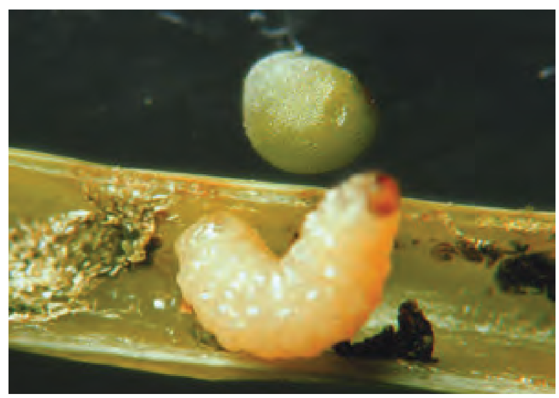


Photo 85. *Cabbage seedpod weevil larva.*

Photo 86. *Imported cabbage worm adult.*

Photo 87. *Imported cabbage worm larva.*

Insect Pest Identification and Control Photos
(Continued, see page 27)

Photo 88. *Southern cabbage worm.*

Photo 89. *Alfalfa looper.*

Photo 90. *Cabbage looper.*

Photo 91. *Beet armyworm.*

Photo 92. *Variegated cutworm.*

Photo 93. *Variegated cutworm damage.*

Photo 94. *Harlequin bug.*

Photo 95. *June beetle.*

Insect Pest Identification and Control Photos
(Continued, see page 27)


Photo 96. *Lygus bug.*


Photo 97. *Red turnip beetle.*


Photo 98. *Thrips.*


Photo 99. *Wireworm.*


Photo 100. *Aster leafhopper.*

Harvest *(see pages 28 – 31 for more information)*


Photo 101. *Canola windrows.*


Photo 102. *Swathing with roller attachment.*


Photo 103. *Canola seed color change.*


Photo 104. *Turned canola seed.*


Photo 105. *Completely turned canola seed.*

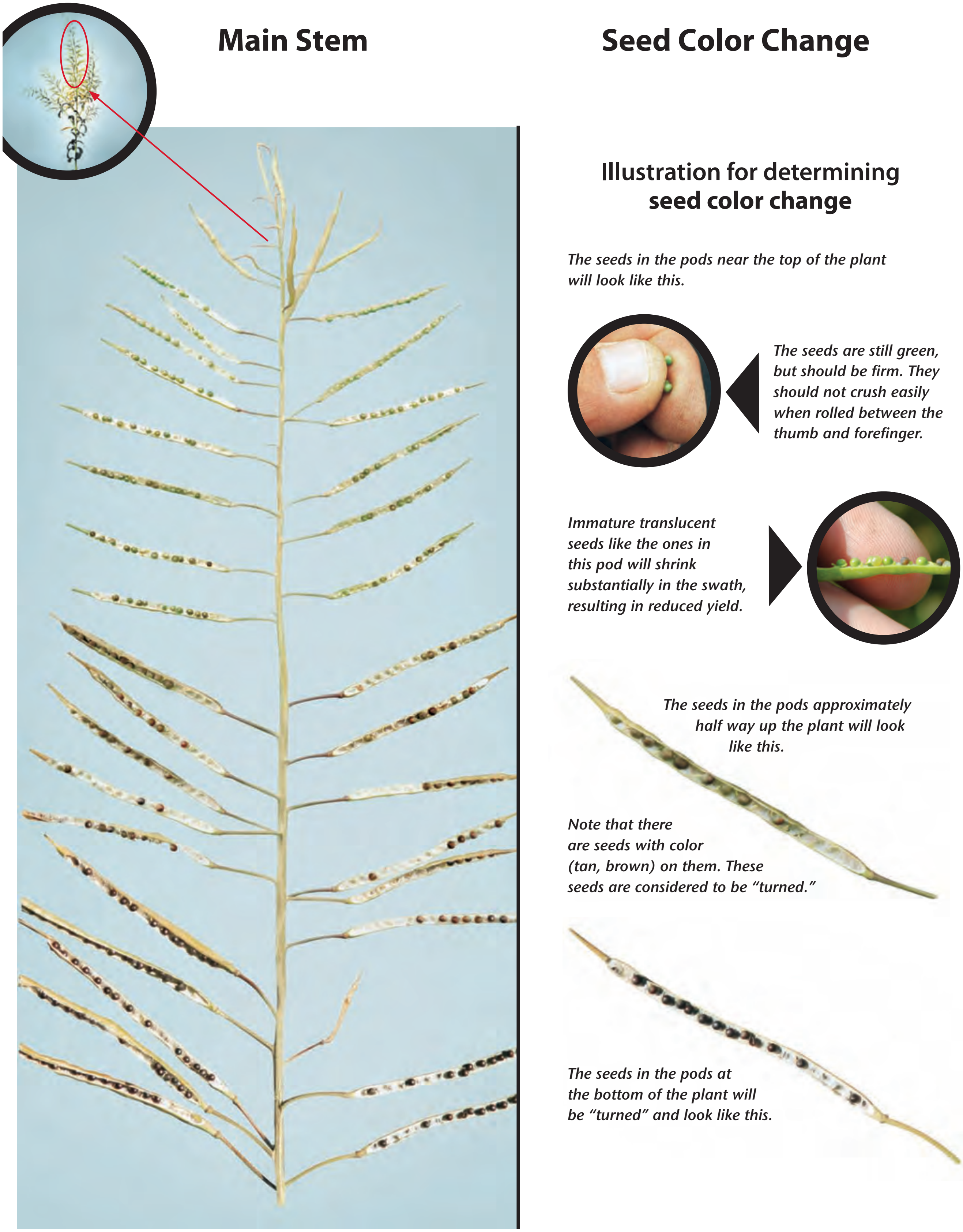

Photo 106. *Pick up header.*


Photo 107. *Direct harvest of ripe canola.*


Photo 108. *Pushing canola.*

Harvest *(see page 29)*

Figure 8. *Seed color change guide for swathing and pushing canola.*



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Additional information related to winter canola production may be found at:

www.agronomy.k-state.edu/extension/
canola.okstate.edu/
www.agronomy.k-state.edu/services/soiltesting/index.html
soiltesting.okstate.edu/
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greatplainscanola.org/
www.uscanola.com/
www.canolacouncil.org/
www.northerncanola.com/
www.agronomy.k-state.edu/services/crop-performance-tests/canola-and-cotton.html
varietytesting.tamu.edu/cool-season-oilseeds/
www.extsoilcrop.colostate.edu/CropVar/
www.cals.uidaho.edu/brassica/growers.asp#field

Publications related to winter canola production may be found at:

www.bookstore.ksre.ksu.edu/
factsheets.okstate.edu/

Budgets related to winter canola production may be found at:

www.agmanager.info
agecon.okstate.edu/budgets/

Publications from Kansas State University are available at: *www.bookstore.ksre.ksu.edu*

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