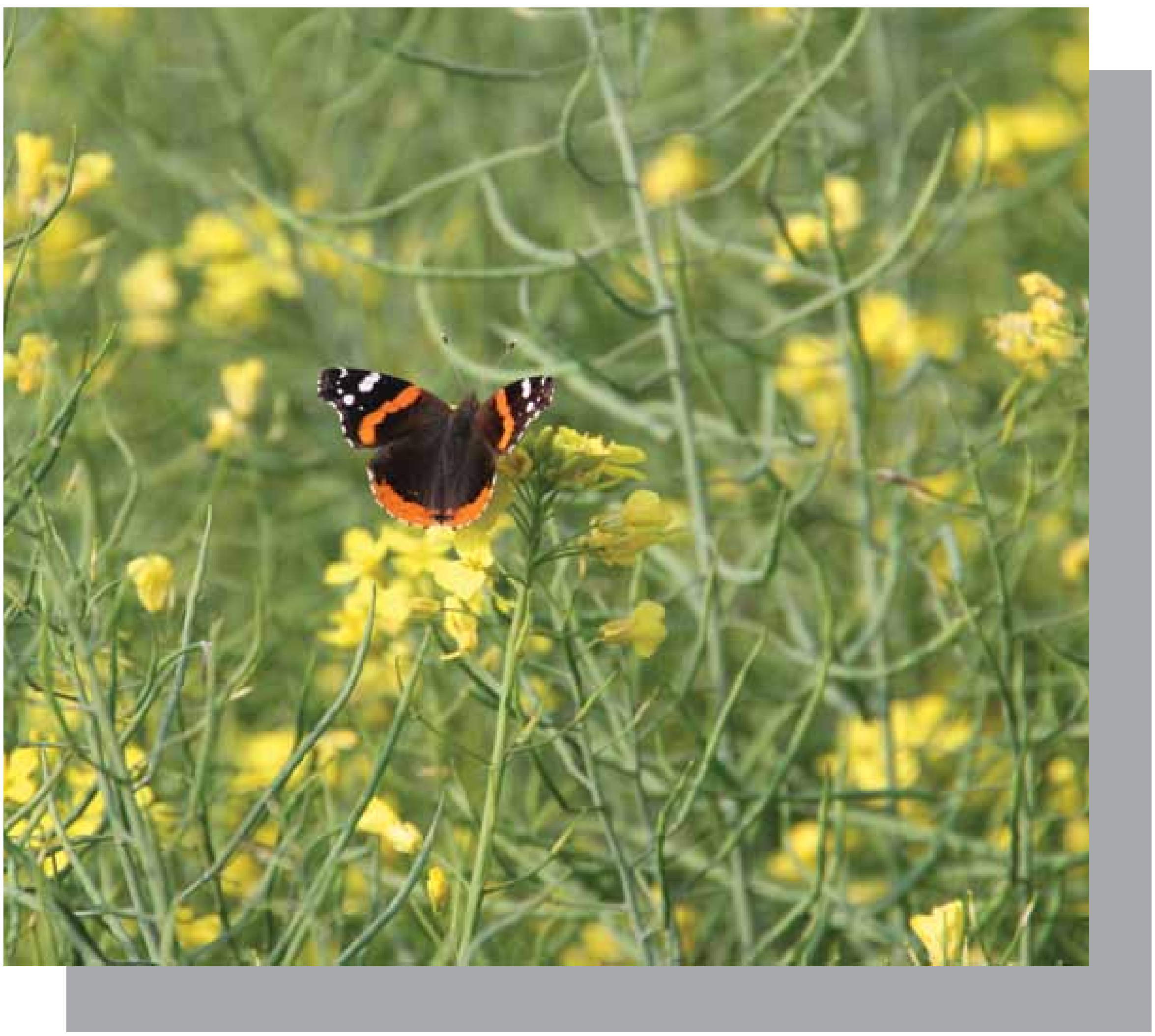
Great Plains Canola Production Handbook



Oklahoma State University • Kansas State University • University of Nebraska
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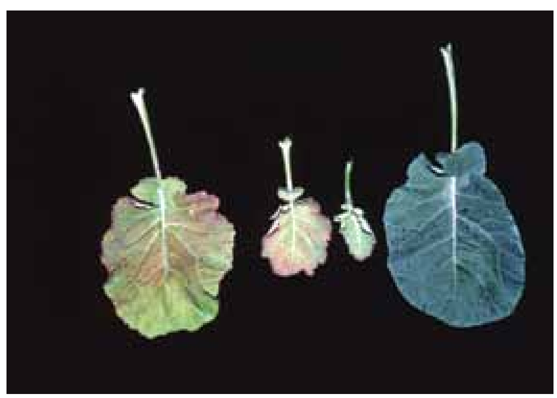
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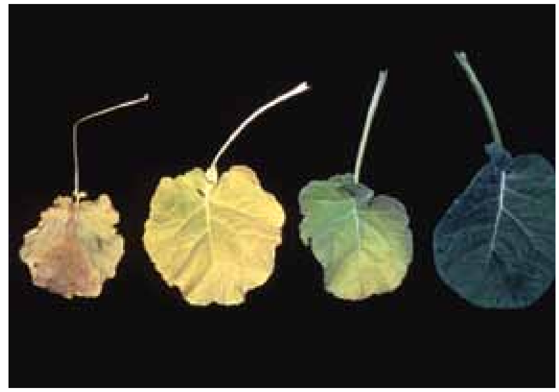

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Co-editors

Mark Boyles, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
Joshua Bushong, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
Heath Sanders, Producers Cooperative Oil Mill, Oklahoma City, Oklahoma
Michael Stamm, K-State Department of Agronomy, Manhattan, Kansas

Contributors

Joe Armstrong, formerly with OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
Brian Arnall, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
John Damicone, OSU Department of Entomology and Plant Pathology, Stillwater, Oklahoma
Eric DeVuyst, OSU Department of Agricultural Economics, Stillwater, Oklahoma
Francis Epplin, OSU Department of Agricultural Economics, Stillwater, Oklahoma
Kristopher Giles, OSU Department of Entomology and Plant Pathology, Stillwater, Oklahoma
Chad Godsey, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
William Heer, KSU South Central Experiment Field, Hutchinson, Kansas
Gary Hergert, UNL Panhandle Research and Extension Center, Scottsbluff, Nebraska
Johnathon Holman, KSU Southwest Research-Extension Center, Garden City, Kansas
Douglas Jardine, K-State Department of Plant Pathology, Manhattan, Kansas
Joshua Jennings, K-State Department of Agronomy, Manhattan, Kansas
Carol Jones, OSU Biosystems and Ag Engineering, Stillwater, Oklahoma
Brad Kard, OSU Department of Entomology and Plant Pathology, Stillwater, Oklahoma
David Mengel, K-State Department of Agronomy, Manhattan, Kansas
Thomas Peeper, emeritus, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma
Dallas Peterson, K-State Department of Agronomy, Manhattan, Kansas
Kraig Roozeboom, K-State Department of Agronomy, Manhattan, Kansas
Tom Royer, OSU Department of Entomology and Plant Pathology, Stillwater, Oklahoma
Curtis Thompson, K-State Department of Agronomy, Manhattan, Kansas
Hailin Zhang, OSU Department of Plant and Soil Sciences, Stillwater, Oklahoma

Summary

Canola is a special 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 cultivars, suitable for the southern Great Plains, are commercially available. This publication discusses aspects of canola production including field and cultivar selection, seeding rates, no-till production, crop growth and development, fertility, weed and insect management, harvest, grain storage, cost-return projections, and insurance.

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Introduction

Canola is a special type of rapeseed. 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 cultivar, Tower, was released. Tower is low in erucic acid and glucosinolates. The term "canola" — CANadian Oil Low Acid — 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 know as "double-low" or "double-zero" rapeseed, or oilseed rape. 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 urged Americans to reduce saturated fat intake. This increased canola oil demand because it contains 7 percent saturated fat, the lowest level of any commercial vegetable 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 other food service entities have publicly announced their current or planned use of canola oil as a *trans* fat-free, low saturated fat cooking oil.

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 cultivars 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 limited acreage. Canola-quality brown mustard (*Brassica juncea*) has been developed over the past few years. All *B. juncea* cultivars are spring planted.

A significant demand for canola oil and meal exists in the United States. In 2009, the United States imported the equivalent of 1.2 million acres of production. From 2000 to 2010, domestic disappearance of canola oil increased from 1,435 to 3,002 million pounds, with more than 80 percent imported (Oil Crops Outlook, 2011). After canola seed is crushed, the remaining meal is used as a protein supplement for livestock. This is important for the southern Great Plains, where a large percentage of beef cattle are fed locally, unlike the northern Great Plains where the meal is shipped out of the region. Nearly 71 percent of the canola meal dispersed is the United States in imported (Oil Crops Yearbook, 2011).

Canola production is increasing to satisfy the growing demand for canola oil and meal. It is well-suited for Great Plains agriculture and shows great promise for expanded acreage because of the large amount of monoculture wheat grown in the region. Small-grain 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, with some yields 50 percent higher, compared to wheat following wheat. 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. In general, winter types have a 20 to 30 percent greater yield potential than spring types. Spring types flower approximately 1 month later than winter types, but are harvested only 2 weeks later because of summer heat. This reduced grain-filling period greatly lowers the yield potential of spring types in the southern Great Plains. Spring cultivars also suffer increased pressure from spring weeds and insect pests. Because of these factors, production of spring types in most of the Great Plains is only recommended for rotations requiring spring planting. Winter survival has been a concern with the winter types in the southern Great Plains. Through cooperative research efforts and public and private breeders, winter-tolerant cultivars have been developed that produce yields that are comparable to other winter canola growing areas of the world. Canola is more management intensive than winter and spring cereals; therefore, field scouting is critical to identify production problems, especially insect pests, before they reach economic thresholds.

Benefits of a Wheat-Canola Rotation

Growing wheat has been a standard farming practice for decades in the southern Great Plains. Over time, a lack of rotation has created numerous production problems that have significantly decreased 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 weed, disease, and insect pressures common to continuous wheat, but in years of severe drought, summer crops often fail. Since 1991, winter canola has been studied as a crop rotation option for winter wheat producers. 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 described below.

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 cultivars allow the use of non-selective herbicides like glyphosate. Most of the winter annual grassy weed species can be reduced or eliminated 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). As a general rule, wheat following canola will have better quality and produce higher yield.

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

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

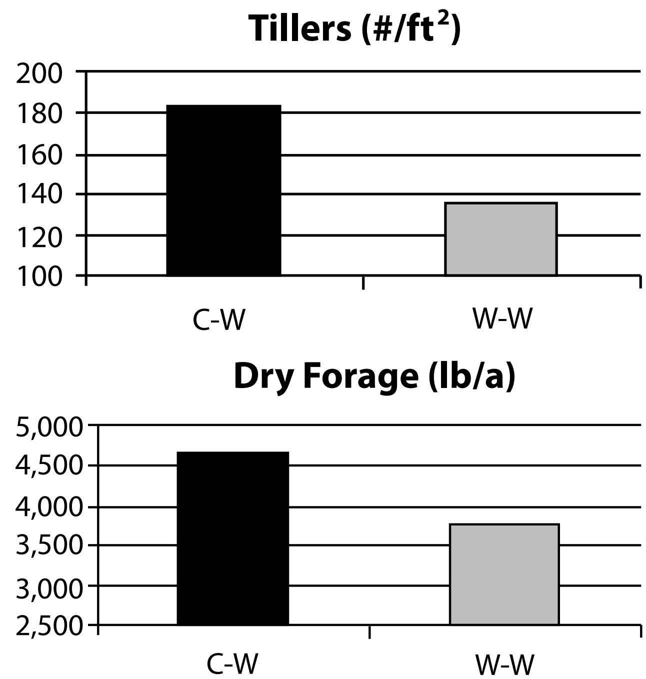
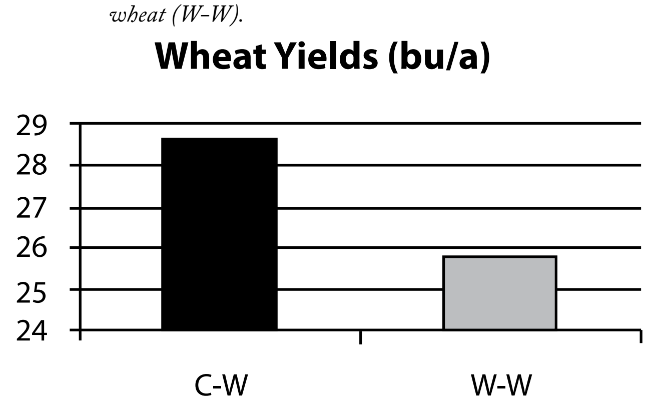


Figure 2. *Comparison of wheat grain yields after canola (C-W) or wheat (W-W).*



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. The southern Great Plains added another canola grain buyer in 2011, meaning producers have more marketing options and delivery points. Most canola oil in the United States is used for human consumption, but it also makes an excellent biofuel feedstock. 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 22 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 40 percent return to annual costs at a 30-bushel-per-acre yield level (Dumler et al., 2012). These budgets do not include the added benefit of cleaner, higher quality wheat following canola. See page 33 for the Oklahoma State enterprise budget.

Field and Cultivar Selection

Canola grows best in medium-textured, well-drained soils, but grows over a wide range of soil textures. Soil pH between 6.0 and 7.0 is optimal. Yields of most cultivars 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). 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. 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 cultivars are sensitive to sulfonylurea herbicide carryover. Follow all herbicide label directions before seeding canola or any other sensitive crop.

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.

Cultivar selection is perhaps the most important decision that is made in growing a canola crop. Therefore, producers should carefully review cultivar characteristics and choose cultivars that match their management style. With more interest in winter canola production in the Great Plains, the number of commercial cultivars is increasing. For information on the latest cultivar characteristics, see Table 3. Also check with local extension offices or local seed dealers for cultivar performance data and seed availability.

A regional breeding program has existed at Kansas State University since 1991. To date, seven cultivars adapted to the region have been released. Three of these cultivars are available from certified seed producers in the southern Great Plains and Kansas Foundation Seeds, Manhattan, Kansas (Table 3). Several private companies are developing and marketing new cultivars targeted for the region as well.

A robust regional and national performance testing system exists to evaluate experimental and commercial cultivars. This system allows for the dissemination of data necessary to ensure the newest and best-adapted cultivars are available to producers. The National Winter Canola Variety Trial is grown at about 50 locations throughout the United States and the results assist producers with cultivar selection. Also, Oklahoma State University coordinates cultivar performance testing across Oklahoma. Information on

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.*

cultivar performance can be found at *www.agronomy.ksu.edu/extension/p.aspx?tabid=91* and *www.oilseeds.okstate.edu*.

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

Winter Survival

An important factor to consider when selecting a cultivar is winter survival (Photo 3). Successful winter survival depends on the genetics of the cultivar, the environment in which it is grown, and the management of the producer. A cultivar should not be planted unless it consistently survives winter conditions in the southern Great Plains. Conditions affecting winter survival are different across the United States. Even though a cultivar 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 months. The cultivars developed specifically for the Great Plains have demonstrated excellent winter survival and performance under stressed and unstressed environments. Before a new cultivar is marketed, it should show adaptability over multiple locations and years. Most commercial cultivars have shown excellent winter survival if they are planted on time.

Sulfonylurea Residual Tolerance

Another important cultivar trait is sulfonylurea residual tolerance. The sulfonylurea class of herbicides is used on nearly 50 percent of all 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 crop rotations of many wheat producers. Cultivars possessing this trait can be safely planted in the fall following application of these herbicides, making canola a viable option for many producers. If fields have a history of sulfonylurea herbicide use within the last year, a tolerant cultivar will need to be planted.

Open-Pollinated vs. Hybrid Cultivars

One key difference among commercial cultivars is that some are hybrids and others are open pollinated. 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. Hybrid seed size is usually 30 to 40 percent larger than open-pollinated cultivars (Photo 4). In the semi-arid Great Plains, this may not always translate into increased yield, but it may make seeding easier. The seed cost of hybrid canola is greater than open-pollinated canola because of the costs associated with producing the seed. Hybrids may display more vigorous fall growth than open-pollinated cultivars, making planting date more critical than for open-pollinated cultivars. Planting too early may result in too much fall growth and an increased potential for winter kill.

Table 3. *Commercially available winter canola cultivars.*

Name	Brand/Distributor[1]	Plant Type[2]	Release Date	Relative Maturity[3]	Herbicide Resistant[4]	Low pH Tolerant
HyClass 115W	Croplan Genetics	OP	2008	E	RR/SURT	---
HyClass 125W	Croplan Genetics	OP	2010	M	RR/SURT	
HyClass 154W	Croplan Genetics	HYB	2008	F	RR	---
Baldur	DL Seeds Inc/Rubisco Seeds LLC	HYB	2004	M	---	---
Dynastie	DL Seeds Inc/Rubisco Seeds LLC	HYB	2009	M	---	---
Flash	DL Seeds Inc/Rubisco Seeds LLC	HYB	2007	F	---	---
Hornet	DL Seeds Inc/Rubisco Seeds LLC	HYB	2007	F	---	---
Safran	DL Seeds Inc/Rubisco Seeds LLC	HYB	2008	M	---	---
Sitro	DL Seeds Inc/Rubisco Seeds LLC	HYB	2007	E	---	---
Visby	DL Seeds Inc/Rubisco Seeds LLC	HYB	2009	E	---	---
Claremore	High Plains Crop Development	OP	2011	F	IMI	---
Riley	Kansas State University	OP	2010	M	---	---
Sumner	Kansas State University	OP	2003	E	SU	---
Wichita	Kansas State University	OP	1999	M	---	---
Chrome	MOMONT, France	HYB	2010	M	---	
Hybrirock	MOMONT, France	HYB	2011	E	---	---
DKW41-10	Monsanto/DEKALB	OP	2008	E	RR	Yes
DKW44-10	Monsanto/DEKALB	OP	2010	M	RR	---
DKW46-15	Monsanto/DEKALB	OP	2008	M	RR/SURT	---
DKW47-15	Monsanto/DEKALB	OP	2008	F	RR/SURT	---
46W94	Pioneer Hi-Bred	HYB	2011	M	RR	---
46W99	Pioneer Hi-Bred	HYB	2011	M	RR	---

[1]*For Croplan Genetics and Monsanto/DEKALB products, contact your local seed dealer for details.*
[2]*HYB=hybrid, OP=open pollinated.*
[3]*E=early, M=medium, F=full.*
[4]*RR=Roundup Ready, SU and SURT=sulfonylurea herbicide carryover tolerant, IMI=imidazolinone carryover tolerant.*

Herbicide Resistance

Producers have the option of selecting cultivars that are Roundup Ready. To control weeds, Roundup Ready cultivars can be sprayed with glyphosate before bolting. This may be an important option to consider if the main objective is to clean up weed-infested fields, especially if winter broadleaf weeds are a major issue.

Low pH Tolerance/Acid Soil Tolerance

A select few commercial cultivars 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 cultivar helps recover some of the lost yield potential, but it is not a long-term, viable solution to correcting the overall problem.

Yield

All commercial cultivars have the genetic backgrounds necessary for producing high yields, but management also plays a significant role. Canola is a crop that responds favorably to timely and sound management practices. While yield is an important factor in cultivar selection, do not use it as the only selection criteria. Look for stable, consistent performance over multiple years and locations when evaluating potential cultivars.

Other Important Traits

Other important traits to consider include relative maturity, heat tolerance at flowering, oil quantity and quality, blackleg resistance, and pod shattering resistance. Seed treatments that include a fungicide and an insecticide should be used to protect against soil-borne diseases and fall insect pressure, respectively. Improved cultivars and hybrids should be available on a regular basis.

Seeding

Small-grain seeding equipment is used to plant canola, but a good seedbed is more critical for establishment than for cereal grains because of the small seed size of canola. Factors such as lack of surface soil moisture, soil compaction, crusting, crop residue, and water logging 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. If the seedbed is too fine or overworked, it loses soil moisture and easily develops a crust. Planting into an overworked seedbed often 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. A moderate amount of crop residue on the soil surface to reduce soil erosion is desirable.

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.

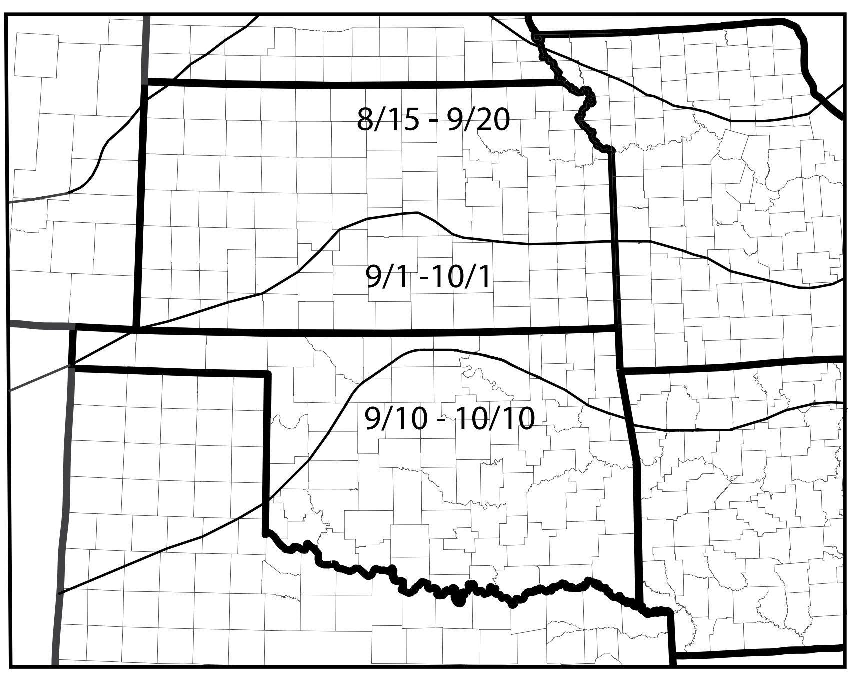
Seeding Date

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. Spring types are planted at similar times to oat planting (March into April). Seeding dates also may be defined by the availability of crop insurance in your area. To receive full protection under multi-peril policies, the planting window for Kansas is September 1 to September 30 and for Oklahoma the planting window is September 10 to October 10. Better winter survival often is observed when planting earlier in the seeding window rather than later. However, sometimes planting too early may result in large plants using excessive water and nutrients. Large plants may exhibit an elevated crown (rosette), especially if the plants are close together. Plants with an elevated crown may have greater 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 125,000 seeds per pound. Hybrid canola seed ranges from 60,000 to 90,000 seeds per pound. Photo 4 illustrates this difference. The seed tag will display the seed count per pound to help determine the appropriate seeding rate. The percent of seed that emerges

Figure 3. *Canola planting dates for the southern Great Plains.*



varies with seed quality, seed germination percentage, soil conditions, and seeding method.

Average seeding rate for open-pollinated cultivars with good seedbed preparation at the optimum planting date is 5 pounds per acre, or about 500,000 live seeds per acre, depending on germination. Similar yields have been obtained for seeding rates of 4 to 10 pounds per acre. A harvest population of four to 15 plants per square foot is optimum. Usually significant yield differences do not occur unless populations at harvest are less than one or greater than 15 plants per square foot. Since hybrid seed is larger, more costly, and the plants tend to be more vigorous, planting rates are based on live seeds per acre. As a general rule, seeding rates for hybrids are approximately 250,000 pure live seeds per acre.

A poorly established crop should be carefully evaluated before destroying it in the early spring. A stand in the spring of only one or two healthy plants per square foot will compensate for wider spacing between plants by developing additional branches. Yield from a stand of this spacing is 60 or 70 percent of the yield from a stand with optimum spacing. Low seeding rates produce thin stands, which can result in uneven maturity. Thin stands also can increase weed problems because the crop cannot form a complete canopy. Even though low plant stands produce relatively good yields, higher seeding rates are recommended. Thick stands promote early, uniform maturity and thinner stalks, which are easier to harvest. However, populations above 15 plants per square foot do not enhance yield and increase potential lodging and disease pressures. High seeding rates may produce smaller, less vigorous plants prone to winterkill.

Reduce the seeding rate by 1 pound per acre for each week before the optimum planting date and increase the seeding rate by 1 pound per acre for each week beyond the optimum planting date. Irrigated fields may be seeded at slightly lower rates than dryland production areas. Drills should be calibrated to ensure desired seeding rates.

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 drilling speed. The optimum drilling speed is about 5 miles per hour. Increasing drilling 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 drilling speed prevents excessive vertical oscillation and improves seed placement. If drilling 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 spacing available on most commercial grain drills is acceptable for canola. Row spacing up to 15 inches has no effect on final yield. Narrower spacing provides quicker canopy closure, reduces broadleaf weed competition, and lessens wind shattering before harvest. Wider row spacing is sometimes used when grain drills cannot be accurately calibrated to seed 5 pounds per acre. Some producers prefer to use wider row spacing to allow better coverage of herbicides on winter annual weeds. Research has shown that spacing of 20 inches or greater may reduce yield by 5 to 15 percent under dryland conditions. At wider row spacings, reduce the seeding rate, as too many plants per foot of row can reduce yield potential because of inner-row competition.

Plants per foot of row can be used to evaluate canola stands (Table 5). Plants per square foot can be used when 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 will develop into viable plants. The numbers were calculated assuming that 65 percent of the seeds planted emerge and the plants survive 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 is one of the most important steps to ensure successful stand establishment. Taking the

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

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 as if it is a separate drill. Seed sizes vary among cultivars, so it is important to recalibrate the drill when changing cultivars. 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.
- Calculate the desired seeding rate based on cultivar 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 will allow 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 = 12.8 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 below to determine how much canola should be caught in each bag based on row spacing and how many rows were collected into one bag. 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.

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

Plugging every other row from the start makes drill calibration easier and helps improve stands.

Broadcast Seeding

Canola drilled at ½- to 1-inch depths into moist soil with a light packing is the best option for rapid, uniform emergence and the most consistent crop establishment. However, 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 the 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 with the drill. 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 will improve 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.0
- 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 be successful planting canola in no-till but careful attention must be paid at seeding. Many producers cannot consider tillage because of conservation programs, or they simply do not want to disturb residue. Success of direct seeding canola into stubble, particularly wheat stubble, has received criticism over the last few years because of 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.

Research shows that no-till stand establishment is not a problem as long as equipment 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. Nonetheless, keeping a stand of canola in no-till over the winter can be more challenging than in conventional till. As a rule of thumb, winter survival will decrease 10 to 20 percent in no-till fields where the stubble is retained and not removed from the seed row or burned.

In no-till, it is best to place 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 will result in a shallow rooted canola plant. Often, the roots may not penetrate the soil surface and simply develop underneath the residue. Achieving uniform seeding depth is more easily done when the previous crop residue has been evenly distributed at harvest. Many no-till seeders work best in the heat of the day when the coulters or disk 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. Using a harrow and burning are useful management tools if residue is not evenly distributed or too thick. If burning is the best option, burn immediately before seeding to help conserve soil moisture.

In heavy residue, an elongation of the canola hypocotyl can be observed. The hypocotyl is defined as the part of the plant that is below the cotyledons and above the seed. An elongated hypocotyl will increase the crown height of the plant. The crown is where the growing point, or rosette, of the plant establishes in the fall. Crown height is important because it is closely related to winter survival. The closer the crown is to the soil surface, the better the chances for complete winter survival. Crown height is a plant characteristic that could be selected for when choosing a cultivar or hybrid.

Soil temperatures in no-till fields will be lower 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 will increase soil temperatures. Using an aggressive coulter or row cleaner may move enough residue to increase soil temperature in the seed row.

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.

Yield of no-till canola is influenced by the same factors that affect establishment. With experience, competitive yields may be achieved under no-till conditions; but at the moment, the risks for stand losses may be greater in no-till fields compared with conventionally tilled fields.

Tips for Successful No-till Seeding

- Give special 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.
- Do not plant if the previous crop's residue is not evenly distributed across the field. Perform a light tillage operation, bale, or burn the residue.
- Plant a winter canola cultivar 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.
- Drilling speed should not exceed 5 miles per hour for planting no-till canola.
- Remove as much residue from the seed row as possible. Switching to 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.
- Avoid seeding canola into fields recently converted to no-till. No-till fields established more than 3 years ago have better soil structure and lower bulk densities, which promote root growth.

Crop Growth and Development

The growth and development of winter canola is divided into easily recognizable growth stages. The length of each growth stage is influenced by temperature, moisture, light, nutrition, and cultivar. 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, pushing 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. A seedling develops its first true leaves 4 to 8 days after emergence (Photo 6). 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 are more susceptible than cereals to environmental hazards, grazing, and insect damage at this stage.

Rosette

The plant establishes a rosette with larger, older leaves at the base and smaller, newer leaves at the center (Photo 7). The root system continues to develop, with secondary roots growing from the taproot. The stem length remains unchanged but its thickness increases. Winter canola overwinters 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 nutrients for growth, and develop a viable crown and root system. This fall growth will sustain 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.

Winter survival is strongly affected by fall growth, the genetics of the cultivar, the environment, and management. To increase the potential for winter survival, plants should develop 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 seven or eight large, true leaves (minimum of three to four leaves), and the canopy height is approximately 6 to 10 inches above ground. Plants smaller than three true leaves have a greater risk of winterkill. Plants larger than 12 inches tall require more soil moisture and may succumb to moisture 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 may reduce survival.

During the winter, growth slows and many visible physical changes take place. These are a result of decreasing temperature and shorter day length. Winter hardening begins after several days of near-freezing temperatures. Cold temperatures set off a chain of plant gene activity to produce or degrade proteins that protect cells. Plants produce smaller cells having a higher concentration of soluble substances more resistant to frost damage. Developed leaves often discolor to white or brown and die. Photos 8 and 9 illustrate the typical winter appearance of semi-dormant canola. In colder areas, 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 cultivar 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 cultivar, all or some parts of the field may turn a shade of purple or red in January and February. Some degree of purpling is normal as plants enter winter dormancy, and the discoloration becomes more obvious with the onset of cold temperatures. There can be many causes for plant purpling, including fertility, insects, herbicide injury, soil type, colder temperatures in low-lying areas, and other environmental conditions. Fertility appears to be the leading cause of plant purpling, because fields that have a higher rate 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 will usually outgrow the purpling, and color can improve with topdressing. Some cultivars 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. New leaves in the spring will 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 to five 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.

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. The flowers open, but the pods fail to develop and eventually fall from the plant. Approximately 40 to 60 percent of the open flowers are developed into productive pods and maintained by the plant until harvest.

Unlike wheat, canola exhibits an indeterminate flowering period that allows it to compensate for yield-limiting factors. If a late-spring freeze or drought occurs during flowering, then the plant may produce more secondary branches to compensate for the buds and flowers that where aborted. A light freeze at flowering will not be damaging. Only the newly opened flowers are lost. A blank area and bend in the raceme will be noticeable after a light freeze, but the canola plant will continue to produce new buds and flowers.

Maturation and Ripening

Maturation begins as the last flowers fade from the main raceme (Photo 13). Flowering continues on secondary racemes for some time. The pod is divided into two halves by a membrane that runs its full length. 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 a reduction in seed yield. The plant only maintains the number of pods it can support through photosynthesis under existing conditions.

Early in seed development, the seed coat expands until it is almost full-sized. The young seed is somewhat translucent as the embryo develops rapidly. Seed weight increases and is complete approximately 35 to 45 days after flowering. The firm green seed holds adequate oil and protein reserves to support future germination and seedling growth. 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 pod set is a critical period in plant development because abiotic and biotic stresses may limit pod development or cause pod abortion, negatively affecting grain yield. 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 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 pistol (female portion) occurs within 24 hours of the release of pollen. Canola plants initiate more buds than they can develop into productive pods. The flowers open but the young pods fail to enlarge and elongate, eventually falling from the plant. This is a natural process. The amount of loss will depend on leaf, stem, and pod health, and the environmental stresses encountered during flowering and pod set. Some of the factors that limit pod set are explained in the following paragraph.

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). Heat stress may have a more negative effect on plant development and yield during early flowering than at pod set. However, oil content of the developing seed may be reduced when heat stress occurs during pod set.

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 likely due to higher levels of the anthocyanin pigment and a lack of chlorophyll in the naturally senescing tissue. Some cultivars 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.

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 will 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 flowers.

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 is 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*), and false chinch bug (*Nysius raphanus*). See the *Insect Pests* section beginning on page 23 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. Two of the more common diseases are Alternaria black spot (caused by various species of *Alternaria*) and the powdery mildew fungus (*Erysiphe cruciferarum*). Both fungal diseases are worse in wet years. See the *Diseases* section beginning on page 20 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, however, 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 plants. 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. Both the Kansas State University Department of Agronomy and the Oklahoma State University Department of Plant and Soil Sciences have downloadable fertilizer recommendation programs available at their soil testing lab websites: *www.agronomy.ksu.edu/soiltesting* and *www.soiltesting.okstate.edu*, respectively. Underestimating the soil fertility needs of winter canola will result in poor plant development, reduced pod set, lower seed quality, and poor yields (Photos 17 – 18)

Subsoil samples for mobile nutrients such as nitrate-nitrogen and sulfate sulfur 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 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, and high nitrogen applications in the fall should be avoided, as they can lead to excessive fall growth and reduced winter survival. While many wheat producers apply all nitrogen fertilizer for wheat in the fall before planting, between one-third and one-half of the total nitrogen for canola (roughly 35 to 80 pounds per acre) should be applied before planting. In addition, 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 normally 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 will react 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, cultivar selection and liming is important for lower pH sites.

Phosphorus and potassium

Phosphorous 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, fertilizer phosphorous and potassium should be broadcast before planting, rather than applied with the drill. Like soybeans and other oilseeds, canola takes up and removes large amounts of phosphorous and potassium. Crop removal in the grain is approximately 0.9 pounds P_2O_5 and 0.45 pounds K_2O per bushel.

General phosphorus fertilizer recommendations for use with canola in Kansas and Oklahoma are given in Table 8. Phosphorous deficiency symptoms include leaf chlorosis and 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, and chlorotic yellowing (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 thio-sulfate. Elemental sulfur or ammonium sulfate can be applied in the fall blended with phosphorus, and incorporated into the seedbed or surface applied with nitrogen in the spring. Soil bacteria must

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 Phosphorus Recommendations		Oklahoma Phosphorus 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 phosphorus 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.*

oxidize elemental sulfur to sulfate before it is available to crops, so sulfur is better applied before planting to ensure availability. Ammonium thio-sulfate or ammonium sulfate can be applied in the spring or fall, but thio-sulfate should not be top-dressed directly on tissue or placed with seed to avoid phyto-toxicity. 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 will 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 having high profile nitrogen levels (>80 pounds per acre) can result in excessive vegetative growth and reduce winter hardiness. Therefore, it is recommended that between one-third and one-half of the total season's nitrogen be applied preplant (roughly 35 to 80 pounds per acre), with the balance being top-dressed 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.

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

It is important 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 will lead to stressed, stunted, nitrogen-deficient plants, which will have a difficult time surviving the winter. A total of 35 to 80 pounds of nitrogen, including profile nitrate available in the fall, appears to improve winter survival. In addition, applying large amounts of nitrogen in the fall can lead to accumulation of nitrate-nitrogen in the vegetation. This can lead to nitrate poisoning of cattle if the canola is grazed.

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

Like most oilseeds, canola is much more sensitive to salt and ammonia injury than wheat or corn. Therefore, producers should be extremely cautious when band applying fertilizers to avoid seed-to-fertilizer contact. The two damaging components are nitrogen and potassium. Fertilizers such as urea (46-0-0), ammoniated phosphates such as MAP (11-52-0), DAP (18-46-0), ammonium thiosulfate (12-0-0-26), or potash (0-0-60) should not be applied in direct contact with the seed. As a general rule, to avoid the risk of seedling injury and stand reduction, fertilizer should be broadcast before planting and not applied with the drill, unless the drill has separate fertilizer openers (such as 2 inch by 2 inch) to avoid seed-to-fertilizer contact. If banding is used, keep nitrogen and potassium rates as low as possible. This may be accomplished using phosphorous sources that are low in nitrogen and potassium, in addition to reducing application rates.

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 (one-half to two-thirds) of the nitrogen should be applied when ambient temperatures are still low and just as plants begin to show increased growth. Top-dress 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.

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.

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 Great 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 (dry-land 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 11.

For soils with 1 percent organic matter, add 15 pounds nitrogen for each yield and nitrate level in Table 11. 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 12 for several currently used soil tests.

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 Great 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 13). Canola takes up large amounts of potassium, and potassium fertilizer should be applied before planting.

Table 11. *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 12. *Phosphorous recommendations for the High Plains.*

Soil test method for phosphorous (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

Table 13. *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 wheat, sorghum, or corn. 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 22 on page 35.

Winter canola has difficulty competing with established weeds at emergence. 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.

Careful attention must be paid when planting most canola cultivars following the application of residual sulfonylurea and imidazolinone herbicides. These products include, but are not limited to, the wheat herbicides Agility SG, Ally, Ally Extra, Amber, Beyond, Finesse, Finesse Grass and Broadleaf, Glean, Maverick, Olympus, Olympus Flex, Peak, PowerFlex, or Rave; corn or sorghum herbicides Accent, Autumn Super, Basis Blend, Beacon, Equip, 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 is listed on the label.

Roundup Ready, or glyphosate-resistant, winter canola cultivars 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 wall-flower (*Erysimum repandum*), wild mustard (*Brassica kaber*), tumble mustard (*Sisymbrium altissimum*), tansy mustard (*Descurainia pinnata)*, flixweed (*Descurainia sophia*), field pennycress (*Thlaspi arvense*), and shepherdspurse (*Capsella bursa-pastoris*) (Photos 37-44). Apply 0.75 pounds of acid equivalent of glyphosate per acre to Roundup-Ready canola from emergence through 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 most 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 14 lists use rates for the various commonly used glyphosate formulations. Experimental cultivars with the Clearfield (imidazolinone) resistance trait are being developed. 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, an 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 impact on yield because canola seedlings do not compete well with weeds. Herbicide application timing proves to have a strong economic effect on yield. According to Figure 4, the best application timing is early fall before canopy closure to allow the canola to establish successfully. Even though more winter annual weeds will likely 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 the 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, then 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 15 provides a general rating for herbicide effectiveness on volunteer canola. These ratings are based on 1 or 2 years of research 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 burn-down application to control emerged glyphosate-resistant volunteer canola. Volunteer canola that emerges before or with the crop may be very 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

Table 14. *Use rates for glyphosate products with various active ingredient (ai) and acid equivalent (ae) concentrations.*

Glyphosate formulation		Glyphosate use rate (0.75 lbs 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. 0.75 pounds of acid equivalent per acre is the standard use rate for glyphosate.*

Figure 4. *Effect of glyphosate application timing on canola grain yields.*

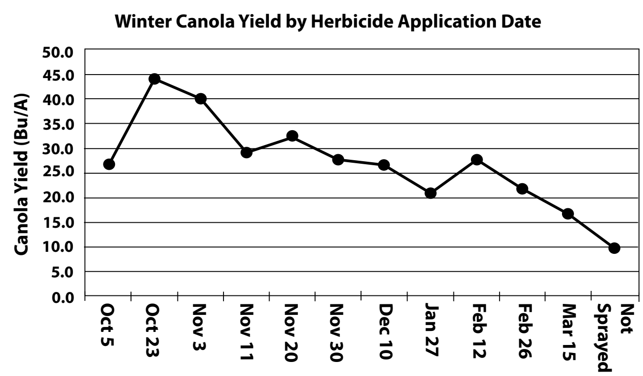


Table 15. *Volunteer canola control in winter wheat.*

Herbicide	Rate unit/acre	Control Rating Fall	Control Rating 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

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, cultivar of canola planted, and winter weather. Nonetheless, producers should be alert to symptoms of low pH effects (Photo 2), nutrient deficiencies (Photos 17 – 27), diseases (Photos 53 – 68), and herbicide injury because these factors are most often yield limiting.

Growth-regulator herbicides and sulfonylurea 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 or pastures and rangeland. Also remember that 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 (Photos 45 – 48). Sulfonylurea herbicides, such as Finesse, Ally, Osprey, Olympus, PowerFlex, and Amber can severely injure canola (Photo 47). As a general rule, sulfonylurea 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 50). Damage from herbicide drift or tank contamination is generally from sulfonylurea herbicides and hormone products like 2,4-D, MCPA, dicamba, and Tordon (picloram). Photos 51 – 52 show typical damage from drift or sprayer contamination of hormone products. 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 on 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 will 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

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, Select, Poast, Finesse, Glean, Harmony Extra

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 such common weeds 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. The recent identification of blackleg in the region suggests that disease incidences will likely increase as canola acres increase.

Blackleg

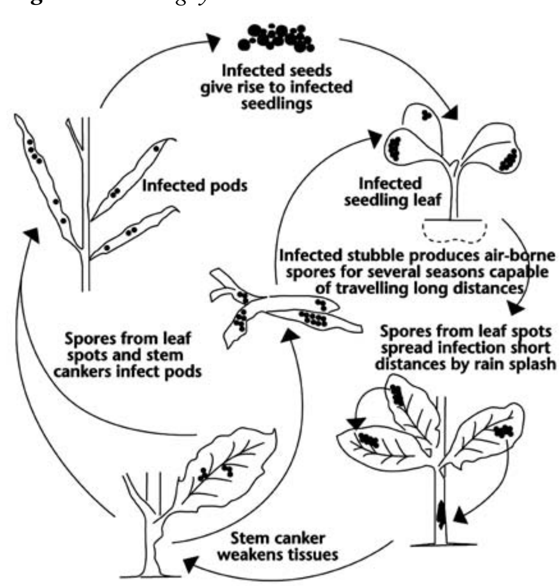
The blackleg fungus, *Leptosphaeria maculans*, is common worldwide and infects canola and related crops. Blackleg is the most serious threat to canola production. The disease creates stem cankers and basal stem decay that causes lodging and premature death and reduces plant growth and yield. There are both mild and aggressive strains of the fungus. The aggressive form 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 strain was recently identified on several farms in Oklahoma including those with the longest history of canola production.

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. 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, pimplelike structures known as pycnidia. Conidia are responsible for increasing disease 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 strain 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 strain can infect early and produce leaf spots as well as stem lesions. Leaf spots (Photos 53-54) 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 55). 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 5.

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 that is effective against blackleg. Several seed treatment products are registered for control of seed-borne blackleg including Acceleron IDL 810, Helix Lite, and Helix XTra (difenoconazole + metalaxyl + fludioxonil + thiamethoxam); Dynasty (azoxystrobin); Prosper

Figure 5. *Blackleg cycle.*



(clothianidin + thiram + carboxin + metalaxyl); and Prosper FX (clothianidin + trifloxystrobin + carboxin + metalaxyl). However, seed treatments will not provide disease control where canola is planted near infested stubble.

If blackleg is observed in a field, till or deep-plow the stubble before canola is planted on other nearby fields. If deep plowed, use minimum tillage or no-till in subsequent crops to avoid bringing infected stubble back to the surface. Blackleg spores can persist in soil up to 5 years. Till blackleg-infested fields last and then thoroughly clean equipment before using in fields where blackleg does not exist. If tillage is not possible, reduce the amount of residue by burning or removing it. 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.

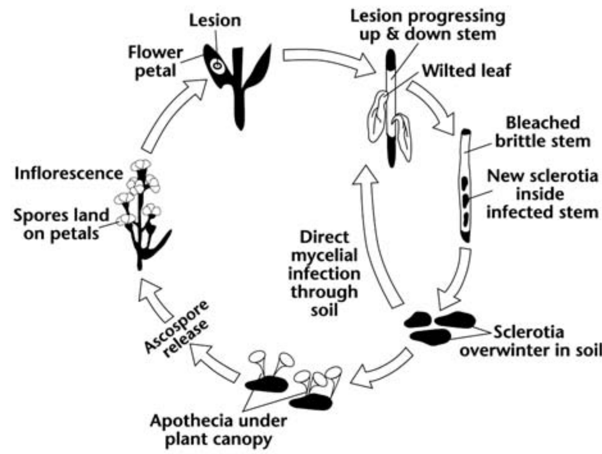
Genetic resistance and crop rotation are the two best methods for managing the disease once it is present. Resistant cultivars are available and most cultivars developed in the Great Plains possess good resistance. Consult local seed dealers and university publications for disease ratings.

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.

The first noticeable symptom of Sclerotinia stem rot is the presence of prematurely ripened plants (Photo 56). 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 57). Hard black structures (Photo 58) 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 59). 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 6.

Figure 6. *Sclerotinia stem rot cycle.*



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 Sclerotinia 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 *Sclerotinia* 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. Endura (boscalid); Quadris (azoxystrobin); and Topsin M, T-Methyl, or Thiophanate Methyl (thiophanate methyl) 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 60 - 61). 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 water-logged 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 62). Stems and roots of affected plants are hollow and rotten when pulled from the ground (Photo 63). Oftentimes root maggots (*Delia* spp.) are present (Photo 64). The best management strategy is to plant a winter-hardy cultivar at the optimum planting date (Photo 65). 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 cultivar on time and to avoid water-logged soils. Cultivars that break winter dormancy early following a warming period and cultivars developed outside the region show the greatest susceptibility.

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 66). 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 67). 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. It is a minor disease in most areas of the Great Plains at this time.

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. This bacterium is seed borne and overwinters in infested stubble. The symptoms of black rot are quite visible, but the disease has not been identified in the Great Plains.

Seedling Disease Complex

Seedling diseases are characterized by failure of seeds to germinate or emerge. 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*. 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 micro-organism). 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 68). Infected plants remain in a vegetative state during the entire growing season and remain greener and taller than uninfected plants at harvest. Aster yellows is spread from plant to plant by the aster leafhopper (*Macrosteles quadrilinetus*) (Photo 78) 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 numerous 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, while 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 16). 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 23 on page 37.

If an insecticide application is warranted, select the insecticide carefully and consider product selection and application timing options that help protect pollinating insects and natural enemies. Cultural practices such as crop rotation, controlling volunteer canola, treating roadside ditches and fencerows for wild mustard, 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. 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.

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); deltamethrin (Decis); gamma-cyhalothrin (Proaxis and Prolex); lambda cyhalothrin (Warrior and other trade names); methyl parathion (Cheminova Methyl); 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 10 years, several pests of canola have emerged in the southern Great Plains, these pests include aphids, army cutworms, diamondback moth larvae, flea beetles, grasshoppers, root maggots, and false chinch bugs.

Aphids

Aphids are the most important insect pest of canola in the southern Great Plains. The green peach aphid (*Myzus persicae*) and the turnip aphid (*Lipaphis erysimi)* (Photos 69-70) 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 71) 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 a seed treatment be recommended 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

Table 16. *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
Flea Beetle				Variegated Cutworm
Grasshopper				Armyworm
				Seed Pod Weevil
				Harlequin Bug

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.

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 72).
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.

Treatment (action) thresholds

Use the treatment thresholds in Table 17 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 very low aphid densities will result 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 73). 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, there are some species of cutworms that in some years can reach levels that are of economical concern in canola.

Adult 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 are nocturnal, feeding at night and hiding during the day. Cutworm damage is characterized by leaves or whole plants cut off at or near the soil surface. Plants will appear notched, wilted, cut-off, or dead (Photo 74). Plants may be missing from rows and bare patches will appear in fields as a result of cutworm feeding, and will sometimes be abundant in patches or specific areas of the field. Cutworm infestations may be worse in sandy soils.

When scouting, it is important to dig into the soil around canola plants a few inches deep and in six to 10 random locations in the field. 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.

Table 17. *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*

Diamondback Moth

The larvae of the diamondback moth *(Plutella xylostella*) frequently infest canola in the southern Great Plains (Photo 75). These larvae are small, green foliage feeders that wiggle violently when disturbed. If present, they produce window paning and shot holes in the leaves (Photo 76).

Diamondback moths are found worldwide. The moths are small and grayish-brown measuring 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 77). Female moths lay flattened, oval-shaped eggs measuring 0.44 mm in groups of 1 to 8 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 measure about 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 infestations in the crown may result in stand loss before spring. Larval infestations of the crown 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 up 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 2 to 3 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.

Flea Beetles

Generally, flea beetles (*Phyllotreta spp.*) (Photo 78) are less of a problem with later plantings of winter canola. 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 79). 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 80). 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. If dry conditions continue with little rainfall, the populations can reach economic thresholds during early pod set. Typically, populations remain low enough 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, false chinch bugs often swarm in groups with thousands of individuals (Photo 81). 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 by examining plants in five or more locations in the field (Photo 82). 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 no allow fall armyworm and cutworm caterpillars the chance to reduce stand.

Occasional Pests

The following are known pests of canola, but 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 83-84). 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 cabbage worms (*Pieris rapae*), **southern cabbage worms** (*Pontia protodice*), **alfalfa loopers** (*Autographa californica*) and **cabbage loopers** (*Trichoplusia ni*) defoliate canola plants in the fall and spring (Photos 85-89). 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 90). Watch for larvae and treat if stands are threatened. **Harlequin bugs** (*Murgantia histrionica*) are occasionally numerous in canola fields at harvest, but thresholds are not well established (Photo 91). **Lygus bugs** (*Lygus spp.*) feed and lay eggs on canola during budding (Photo 92). 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 93). 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 94). **Wireworms** are the larvae of various species of click beetles and can be a potential pest as they are in many other crops (Photo 95). They can be managed with seed treatments if problems are anticipated before planting. **Aster leaf hopper** (*Macrosteles quadrilinetus*) causes the spread of aster yellows (Photo 96). No treatment thresholds are available. **Bird damage** can severely reduce yields; areas close to large flocks of geese, blackbirds, 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 high grain yield. Also, the forage produced by treated canola seed cannot be grazed according to product labels. Thus, if canola forage is 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 cultivars with prostrate rosettes yielded similarly to ungrazed check cultivars. Thus, new dual-purpose cultivars are being developed. One such cultivar, 'Griffin', will be available to producers in 2013.

Canola forage is slightly lower in protein, lower in fiber, and higher in energy than wheat (Table 18). 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.

Table 18. *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

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 cultivars 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 pushed, swathed, or desiccated to assist in harvest or it can be direct combined. Determining which option to use is a management decision for the grower because all can be done successfully if performed correctly. Pushing canola is a good method to use on tall, thick canola. Swathing is recommended if canola is planted on a large number of acres. Desiccation is used if access to other harvest aids is limited and the crop exhibits uneven maturity. Direct combining requires no additional equipment for canola producers. Harvesting canola is a slower process than harvesting wheat.

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 ready and it should be harvested before wheat, otherwise crop losses will occur. Losses from pod shattering due to excessive wind, rain, and hail can be devastating, resulting in yield losses greater than 50 percent when the crop is ripe.

Pushing

Pushing is a relatively new procedure for canola harvesting in the southern Great Plains that has been suggested as a faster and less expensive alternative to swathing. 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 97). Mounting a pusher on front loader brackets has not been successful because the unit is too wide and heavy. The pusher must be kept level during this high-speed operation. By pushing the canola 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 therefore less shattering occurs.

Although experience with pushing is limited, it may work better in some crop 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. 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 still ripen naturally, but it will be better protected from shatter losses. 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.

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.

Swathing

Swathing helps to reduce shatter losses from wind and hail. When swathing, it is important that the plant is at the correct stage of maturity. For optimum seed yield and quality, the best time to swath is 40 to 60 percent seed color change observed on the main raceme and 30 to 40 percent seed moisture. Canola can be swathed at 30 to 70 percent seed color change without sacrificing significant yield or quality; this provides a wider “swathing window” for producers. In hot, windy, and dry conditions, canola matures quickly and seed color change can increase by 10 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 98). At this time, the canola can be harvested with a pickup header. Since there is a somewhat large window for swathing, it is a great option if the crop maturity is uneven across the field. Swathing terminates the plant and forces ripening. This allows the crop to be harvested sooner than if it ripened naturally. It is an attractive option to many producers since they can harvest swathed canola before wheat. Swathing too early will result in green seed, lower oil content, and higher seed moisture. Swathing too late will result in excessive shattering.

Swathing during hot (85 degrees Fahrenheit), dry, and windy weather will stop 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. Swath can be done when there is heavy dew or a light drizzle. The draper, belt-style of swather is superior to the auger style in reducing crop damage.

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 disease potential. 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. Set the roller at a height that will slightly force the windrow into the stubble. The stubble will act as an anchor and help 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 only. Using the seed color change chart (see Figure 7 in color pages), take note of the seed color change percentage on the main raceme. Seeds in pods on the bottom one-third of the main raceme mature first. 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 to be "turned" (Photo 99). Most of 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 100). The bottom one-third should be turned and completely reddish-brown or brown-black (Photo 101). 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 seeds, estimate the average percent seed color change for that field. Continue inspections every 2 to 3 days to monitor color change. Seed color is more important than the overall field, straw, or pod color when gauging the optimum time to swath.

Some producers are mistakenly swathing canola too early, at around 10 to 15 percent seed color change. At this stage, many seeds on the side branches may be watery and translucent. If this represents 30 percent of seeds, producers may be sacrificing a large proportion of yield by swathing too early. Watery, translucent 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 due to accelerated dry-down and seed shrinkage. Shattering losses will 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. In addition, the key to properly curing the crop in a windrow is having adequate seed moisture to naturally clear chlorophyll.

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 loses from swathing.

Advantages of swathing canola

- Harvest 8 to 10 days earlier.
- Earlier harvest increases opportunities for double cropping.
- Greater flexibility with large acreages since harvest timing is not as critical as direct combining.
- Swathing can be performed around the clock.
- 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 bin.
- 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.
- Swathing is advantageous if weather conditions conducive to shattering are eminent (hail, hard rain, high winds).

Disadvantages of swathing canola

- Some research has shown from 0 to 10 percent yield reduction when plots were swathed at the optimum stage compared to direct combining.
- Do not swath 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 excessive seed shrinkage.

- Swathing too early results in excessive seed shrinkage and swathing too late results in excessive seed shatter.
- Additional equipment and a second pass over the field are required.
- Once the crop is swathed, the seed does not continue to fill. Seed swathed before achieving its full complement of oil and protein will not accumulate any more after swathing. This reduces yield, oil, and protein content and may increase green seed count.
- 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. Swath rollers that lightly push the windrow down into the standing stalks reduce the risk of blowing (Photo 102).

Combining swathed canola

Canola that is swathed is ready to harvest when seed moisture has dropped under 10 percent. Under normal conditions, this is about 5 to 10 days after swathing. Most seeds will 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, it may be left longer to clear more green seed. Only a small percentage of green seeds will reduce the grade. By leaving windrows to reduce green seed count, the risks for prolonged wet weather delays and for yield and quality losses from severe weather events are increased.

Windrows are best picked up by using draper belts with rubber or synthetic fingers (Photo 103). 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 where plants are excessively lodged, weed infestations are heavy, maturity is not uniform, or the crop is not going to be swathed or pushed. Desiccant use is also popular where swathing and pushing equipment are not readily available. Diquate 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 course 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.

The recommended stage of growth for applying diquat on canola is 60 to 75 percent seed color change, which is beyond the optimum stage for swathing canola. 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 in canola to kill green plant material to facilitate harvest. "Contact" 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 counts 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 whipping and shattering in the wind. The final decision on whether to direct combine must be made before the optimal swathing stage (up to 70 percent seed color change).

Direct combining is often recommended for southern Great Plains producers because dry-down happens quickly because of warm air temperatures (Photo 104). 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 will cause larger, higher-yielding seedpods to shatter. Harvesting at slightly higher moisture content

(10 to 15 percent) and then drying down in a bin may reduce the effects 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 will keep 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.

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. Producers who successfully direct harvest say that experience leads to success. If straight combining for the first time, start with a small number of acres. This will allow for experimentation with one's own equipment.

Advantages to direct combining

- Best opportunity to deliver No. 1 quality grain because of reduced green seed potential.
- Able to combine during hot, greater than 85 degrees Fahrenheit, dry weather conditions and maintain quality.
- 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 way 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 promotes decay of the seed pod.

General 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.
- In general, ground speed is slower than wheat.
- Harvest canola immediately below the seedpods to avoid excessive trash and green stems moving through the combine and slowing harvest.
- 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 and do not grind the stems. 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.
- Work around low spots of late maturity and high weed biomass. These will slow harvesting down and any green plant material in the sample increases spoilage. Harvest these areas later.
- Following the combine, about 130 to150 seeds per square foot equals 1 bushel per acre (50 lb) of loss.

Storage

Successful canola storage requires cool, dry conditions. Therefore, 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 8 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.

Figure 8. *Safe and spoilage conditions for canola adapted from Mills (1996).*

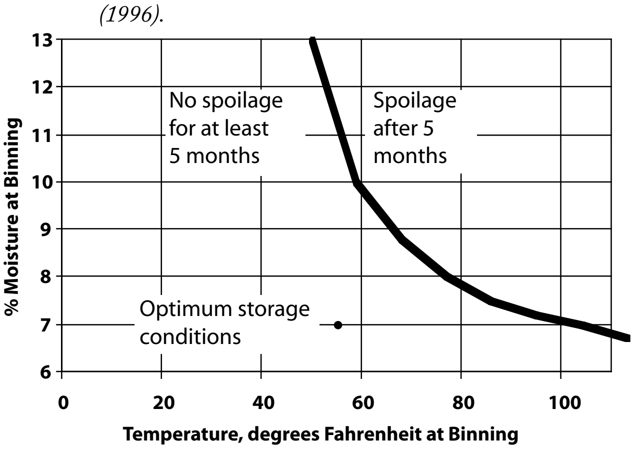


Table 19. *Equivalent relative humidity and temperature influence on seed moisture content. (NDSU 2005).*

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

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. Therefore, 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.

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 cultivars appropriate for the Great Plains average 40 percent oil content. Table 19 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 19. 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, which are 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 20 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 will continue to move through the stored seed. The moisture will redistribute through the seed and spoilage should not occur.

Table 20. *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.

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.

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.

Budgets

Table 21 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 regions in Kansas are available online at *www.agmanager.info/crops/budgets/proj_budget.*

Table 21. *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	$6.00	40	240.00	43	258.00				
Canola	lbs	$0.24					2,050	492.00	2,050	492.00
Gross Returns	acre			$240.00		$258.00		$492.00		$492.00
"Cash" Costs										
Wheat Seed	bu	$14.00	1	14.00	1	14.00				
Canola Seed (RR + tech fee + treatment)	lbs	$5.40					5	27.00		
Canola (Conventional, treated)	lbs	$3.00							5	15.00
Anhydrous Ammonia (82-0-0)	lbs	$0.43	68	29.24	76	32.68	36	15.48	36	15.48
Fertilizer Application	acre	$12.00	1	12.00	1	12.00	1	12.00	1	12.00
Urea (46-0--0)	lbs	$0.89					106	94.77	106	94.77
DAP (18-46-0)	lbs	$0.89	50	44.50	50	44.50	50	44.50	50	44.50
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	$17.17	1	17.17	1	17.17				
Herbicide (e.g. Select®)	oz	$0.84							9	7.59
Herbicide (e.g. Assure II®)	oz	$0.98							8	7.81
Herbicide Additive (Crop Oil Concentrate)	ac	$1.25							2	2.50
Herbicide (Roundup PowerMax (glyphosate))	oz	$0.11					44	4.83		
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					1	3.67	1	3.67
Insecticide (e.g. Warrior) Spring	oz	$3.67					3	11.02	3	11.02
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	$7.00	1	7.00	1	7.00				
Canola Crop Insurance	acre	$16.00					1	16.00	1	16.00
Fuel	gallon	$3.50	4.92	17.22	4.92	17.22	4.92	17.22	4.92	17.22
Lube	acre			2.58		2.58		2.58		2.58
Repair	acre			7.12		7.12		7.12		7.12
Annual Operating Capital	$	$0.07	183.96	6.44	187.40	6.56	286.99	10.04	286.91	10.04
Wheat Custom Harvest & Haul										
Base Charge	acre	$21.00	1	21.00	1	21.00				
Excess for > 20 bu/a	bu	$0.21	20	4.20	23	4.83				
Hauling	bu	$0.23	40	9.20	43	9.89				
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					21	4.41	21	4.41
Hauling	bu	$0.23					41	9.43	41	9.43
Total "Cash" Costs	acre			$225		$230		$347		$347
Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management	acre			$15		$28		$145		$145

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 were 26 bushels in 2009 and 32 bushels in 2010. Producer-reported yields from 2011 were not available at the time of this publication. Research plot data, taken from five Oklahoma sites, shows an average yield of 48 bushels for 2011. 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 2,050 pounds (41 bushels) per acre for canola is approximately 85 percent of the wheat yield (when yields of both wheat and canola are measured in pounds 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 50 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 68 pounds per acre of anhydrous ammonia (82-0-0). For an expected yield of 2,050 pounds per acre of canola and an expected requirement of 0.05 pounds of nitrogen per pound of canola, a total of 103 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 36 pounds of 82-0-0. The remainder is top-dressed using 50 pounds of DAP (18-46-0) and 108 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 top-dress 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 cost 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.

Crop Insurance

Canola and rapeseed that is planted for harvest as seed 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 inter-planted 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. There are currently 10 insurance program counties in Oklahoma: Alfalfa, Blaine, Caddo, Custer, Dewey, Garfield, Grant, Kingfisher, Major, and Woods. 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 Kansas is September 1 to September 30 and in Oklahoma it is September 10 to October 10. 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. 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. Visit http://www.rma.usda.gov/aboutrma/fields/ok_rso/ for a current commodity insurance fact sheet.

Table 22. *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 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 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 **Post emergence:** 0.75 lbs acid equivalent/a	**Active Ingredient:** Glyphosate **Similar Products:** Many. Rates and required adjutants 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.

Table 22. *Continued on page 36*

Table 22. *Canola weed control suggestions.* *Continued from Page 35*

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
Select Max 0.97 lb ai per gallon 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 Oklahoma 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.
Sonalan HFP 3 lb ai per gallon 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.** 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 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 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.** 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 23. *Management of insect and mite pests in canola. Read and follow all label directions before product use.*

Pest	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)	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)	1 pt	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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
		Planting: Research data indicates 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).
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
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)
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).

Table 23. *Continued on page 38*

Table 23. *Management of insect and mite pests in canola. Continued from page 37*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
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	21-day PHI for harvest. Do not make applications less than 5 days apart
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		Proaxis 0.5 CS (3)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).

Table 23. *Continued on page 39*

Table 23. *Management of insect and mite pests in canola. Continued from page 38*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
Harlequin bug	Black, shield-shaped, with orange, red, and yellow markings. Measures 3⁄8 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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing. (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).

Table 23. *Continued on page 40*

Table 23. *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
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).
		Methyl parathion (1B)	1 pt	28-day PHI for harvest. Do not graze treated fields.
		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)	3.84 fl oz	30-day PHI for harvest or grazing.
		Warrior with Zeon (3) (lambda cyhalothrin)	3.84 fl oz	30-day PHI for harvest or grazing (other names: Grizzly Z, Lambda Cy, Silencer, Tiaga).
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.*

Preharvest intervals and grazing restrictions

Azadirachtin (neem)	0 day PHI for harvest
Bacillus thuringiensis	0 day PHI for harvest
Battalion[r]	7-day PHI for harvest
Brigade[r]	35-day PHI for harvest
Helix XTra	No PHI listed. Do not graze
Methyl parathion[r]	28-day PHI for harvest. Do not graze treated fields
Mustang[r] MAX	7-day PHI for harvest
Prosper FX	No PHI listed
Proaxis[r]	30-day PHI for harvest or grazing
Warrior[r]	30-day PHI for harvest or grazing

[r] = *restricted use*

Taken from Current Report CR-7667, *Management of Insect and Mite Pests in Canola*, Oklahoma Cooperative Extension Service.

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Disease Photos *(Continued, see pages 21 – 22)*


Photo 57. *Sclerotinia stem.*


Photo 58. *Sclerotia in stem.*


Photo 59. *Sclerotinia apothecia.*


Photo 60. *Alternaria black spot leaf.*


Photo 61. *Alternaria black spot stem.*


Photo 62. *Swollen crowns.*


Photo 63. *Crown and root rot.*


Photo 64. *Root maggot.*

Disease Photos *(Continued, see pages 22)*

Photo 65. *Varietal differences in susceptibility to winter decline syndrome.*

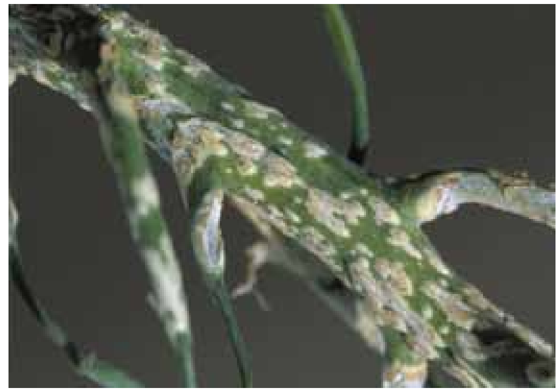


Photo 66. *Downy mildew.*

Photo 67. *Powdery mildew.*

Photo 68. *Aster yellows.*

Insect Pest Identification and Control Photos

(see pages 23 – 24 for more information)

Photo 69. *Green peach aphid.*

Photo 70. *Turnip aphid.*

Photo 71. *Cabbage aphid.*

Photo 72. *Aphids on canola.*

Insect Pest Identification and Control Photos

(Continued, see pages 24 – 25)

Photo 73. *Army cutworm.*

Photo 74. *Army cutworm damage.*

Photo 75. *Diamondback moth larva.*

Photo 76. *Diamondback moth larvae feeding damage.*

Photo 77. *Diamondback moth adult.*

Photo 78. *Flea beetle.*

Photo 79. *Cabbage root maggot.*

Photo 80. *False chinch bug.*

Insect Pest Identification and Control Photos

(Continued, see pages 25 – 26)

Photo 81. *False cinch bug on plant.*

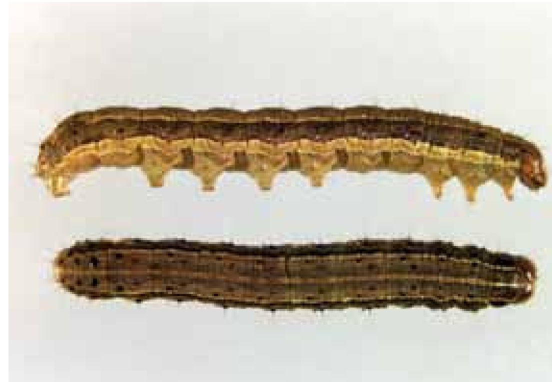


Photo 82. *Fall armyworm.*

Photo 83. *Cabbage seedpod weevil adult.*

Photo 84. *Cabbage seedpod weevil larva.*

Photo 85. *Imported cabbage worm adult.*

Photo 86. *Imported cabbage worm larva.*

Photo 87. *Southern cabbage worm.*

Photo 88. *Alfalfa looper.*

Insect Pest Identification and Control Photos

(Continued, see page 26)

Photo 89. *Cabbage looper.*

Photo 90. *Beet armyworm.*

Photo 91. *Harlequin bug.*

Photo 92. *Lygus bug.*

Photo 93. *Red turnip beetle.*

Photo 94. *Thrips.*

Photo 95. *Wireworm.*

Photo 96. *Aster leafhopper.*

Harvest *(see pages 27 – 29 for more information)*

Photo 97. *Pushing canola.*

Photo 98. *Canola windrows.*

Photo 99. *Canola seed color change.*

Photo 100. *Turned canola seed.*

Photo 101. *Completely turned canola seed.*

Photo 102. *Swathing with roller attachment.*

Photo 103. *Pick up header.*

Photo 104. *Direct harvest of ripe canola.*

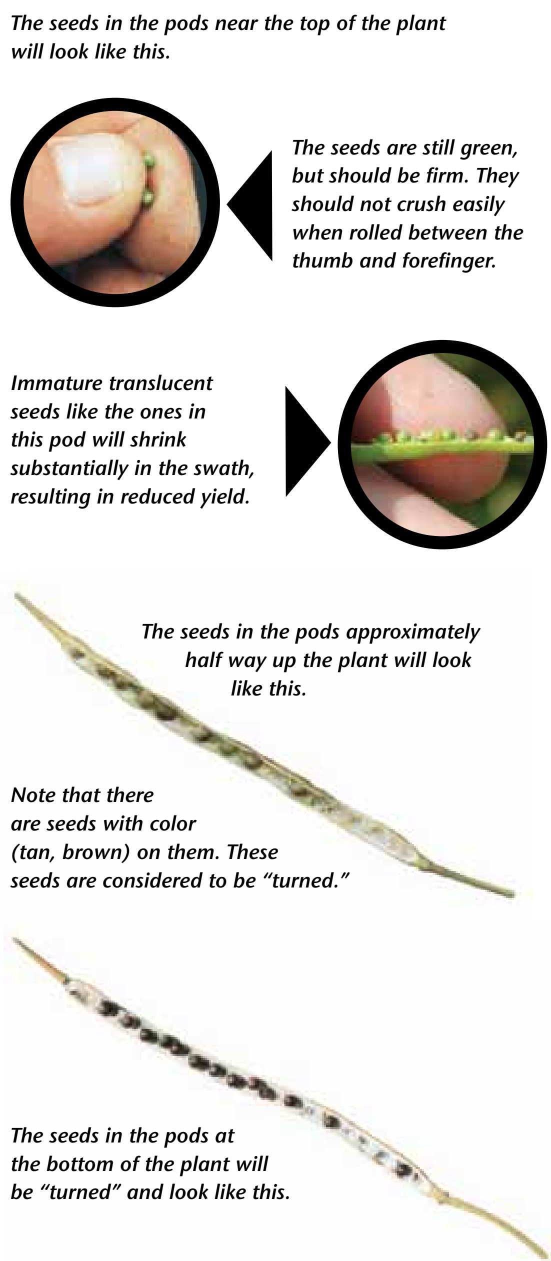
Harvest *(see page 28)*

Figure 7. *Seed color change guide for swathing and pushing canola.*

Main Stem

Seed Color Change

Illustration for determining seed color change



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

www.agronomy.ksu.edu/extension/p.aspx?tabid=60
www.canola.okstate.edu/index.htm
http://oilseeds.okstate.edu/variety-trials
www.soiltesting.okstate.edu/
www.agronomy.ksu.edu/SoilTesting/
http://greatplainscanola.org/
www.uscanola.com/
www.canola-council.org/
www.canolau.com/
www.northerncanola.com/
www.cals.uidaho.edu/brassica/index.html
www.extsoilcrop.colostate.edu/CropVar/

Publications related to winter canola production may be found at:

www.ksre.ksu.edu/library/crpsl2/mf2734.pdf
www.canola.okstate.edu/productionguides

Budgets related to winter canola production may be found at:

www.agecon.okstate.edu/extension/
www.ksre.ksu.edu/library/agec2/mf2421.pdf

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