Great Plains Canola Production Handbook

Oklahoma State University • Kansas State University • University of Nebraska

March 2009

Canola Photos

(see pages 1 – 5 for more information)

Photo 1. *Seeds, oil, and meal.*

Photo 2. *Low pH symptoms.*

Photo 3. *Genetic differences in winter survival.*

Photo 4. *Canola seedling.*

Photo 5. *Rosette.*

Photo 6. *Bolting.*

Photo 7. *Flowering.*

Photo 8. *Maturation.*

Canola Photos *(Continued)*

Photo 9. *Ripening.*

Photo 10. *Semi-dormant winter canola.*

Photo 11. *Natural leaf color change.*

Photo 12. *Flowering at 4 weeks.*

Weed Control Identification Photos (see pages 10 – 11 for more information)

Photo 13. *Henbit.*

Photo 14. *Common chickweed.*

Photo 15. *Cheat, Japanese brome, and downy brome.*

Photo 16. *Rescuegrass.*

Weed Control Identification Photos *(Continued)*

Photo 17. *Feral rye.*

Photo 18. *Jointed goatgrass.*

Photo 19. *Italian ryegrass.*

Photo 20. *Wild oat.*

Photo 21. *Volunteer wheat.*

Photo 22. *Blue mustard.*

Photo 23 and 24. *Bushy wallflower and wild mustard.*

Photo 25. *Tumble mustard.*

Weed Control Identification Photos *(Continued)*


Photo 26. *Flixweed.*


Photo 27. *Flixweed (top) tansy mustard (bottom).*


Photo 28. *Field pennycress.*


Photo 29. *Shepherdspurse.*

Pesticide Damage Photos (see page 11 for more information)


Photo 30. *Sulfonylurea contamination in spray tank.*


Photo 31. *Glyphosate injury to non-glyphosate resistant canola.*


Photo 32. *Herbicide residue carryover.*


Photo 33. *Herbicide residue carryover.*

Pesticide Damage Photos *(Continued)*

Photo 34. *Herbicide residue carryover.*

Photo 35. *Herbicide residue carryover.*

Photo 36. *Herbicide residue carryover.*

Photo 37. *Herbicide residue carryover.*

Photo 38. *Sulfonylurea drift or sprayer contamination.*

Photo 39. *Sulfonylurea drift or sprayer contamination.*

Photo 40. *Typical hormone injury.*

Photo 41. *Typical hormone injury.*

Pesticide Damage Photos *(Continued)*

Photo 42. *Typical hormone injury.*

Disease Photos (see pages 12 – 14 for more information)

Photo 43. *Blackleg leaf.*

Photo 44. *Blackleg leaf.*

Photo 45. *Blackleg stem.*

Photo 46. *Plants infected with sclerotina.*

Photo 47. *Sclerotinia stem.*

Photo 48. *Sclerotia in stem.*

Disease Photos *(Continued)*

Photo 49. *Sclerotinia apothecia.*

Photo 50. *Alternaria black spot leaf.*

Photo 51. *Alternaria black spot stem.*

Photo 52. *Downy mildew.*

Photo 53. *Aster yellows.*

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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). Cold-tolerant winter varieties, suitable for the Great Plains, are commercially available and heat-tolerant spring varieties are under development. This publication discusses aspects of canola production including field selection and crop rotation, variety selection, crop growth and development, seeding rates and seed placement, fertility, weed management, diseases, insect management, harvest, storage, and cost-return projections.

Acknowledgements

Major funding for this publication was provided by the Oklahoma State University Pesticide Safety Education Program. Additional funding was provided by the Great Plains Regional Canola Research Program, which is part of the National Canola Research Program, United States Department of Agriculture, Cooperative States Research Education and Extension Program Supplemental and Alternative Crops Competitive Grants Program; the Kansas Agricultural Experiment Station; and the Oklahoma Agricultural Experiment Station.

Contents

Great Plains Canola Production Handbook was published at Kansas State University in cooperation with the University of Nebraska Lincoln and Oklahoma State University.

Introduction

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

Oilseed rape was reportedly grown in Europe 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 as lamp oil and for lubrication. During World War II, Canada grew millions of acres for use as a marine lubricant, but production declined as diesel engines replaced steam engines.

Canada began developing the first oilseed rape with low levels of erucic acid in the oil in 1957 to meet the demand for cooking oil. Interest in low erucic acid rapeseed increased, and Canadian production reached 1 million acres in 1965. In 1974, Tower was released. Tower is low in erucic acid and glucosinolates, becoming the first true canola variety. The term "canola" was trademarked by the Western Canadian Oilseed Crushers Association in 1978 and is used to describe rapeseed genetically low in erucic acid and glucosinolates, "CANadian Oil Low Acid." In 1985, the U.S. Food and Drug Administration conferred "generally recognized as safe" (GRAS) status to rapeseed oil with less than 2 percent erucic acid. One year later, the American Heart Association urged Americans to reduce saturated fat intake. This increased demand for canola oil because it contains 7 percent saturated fat, the lowest level of any commercial, non-genetically modified 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 due to its unsaturated fat content. 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. *Brassica rapa,* also called *B. campestris,* Polish rape, summer turnip rape, or field mustard, has many canola-quality cultivars and is grown on a limited acreage. *Brassica juncea*, brown mustard lines with canola-quality, were developed and released over the past few years. All *B. juncea* cultivars are spring planted and are better adapted to the High Plains region of the Great Plains. Winter canola varieties grown in the southern Great Plains are developed from *B. napus.*

Canola production 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. In 2006 to 2007, the United States imported the equivalent of 1 million acres of production (Oil Crops Outlook, 2008). In addition, a domestic market for the oil and meal exists and continues to grow. It is estimated that from 2007 to 2008, domestic disappearance increased from 1,925 to 2,393 million pounds of canola oil (Oil Crops Outlook, 2008). More than 80 percent of the canola oil consumed in the United States is imported. Canola breeding and commercial production in the United States are increasing to satisfy the growing demand for canola oil. 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. Small-grain equipment can be used to plant and harvest canola. According to canola growers in the region, yields of winter wheat following canola have shown a 10 to 20 percent increase compared to wheat following wheat, with some fields as high as 50 percent. A positive rotational effect is present when including canola in a winter wheat cropping system.

Both spring and winter types of canola are available and 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 varieties 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 region. However, through cooperative research efforts and public and private breeders, cold-tolerant varieties have been developed that produce competitive yields. 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.

Field Selection and Rotation

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, and yields of most varieties may be reduced significantly where pH is below 5.5. Low pH symptoms will be seen in the fall as crinkled, cupped, or strapped leaves (Photo 2). 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

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.

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

Variety Selection

An important factor to consider when selecting a variety for the Great Plains is winter survival (Photo 3). A variety should not be planted unless it consistently survives winter conditions in a given area. Conditions affecting winter survival are different for various regions. Even though a variety survives well in areas with lower minimum temperatures than those in the Great Plains, it may not tolerate the rapid fluctuations in temperatures characteristic of the area. The varieties developed specifically for the Great Plains have demonstrated excellent winter survival in the region. Varieties possessing Roundup Ready® herbicide resistance, insecticide seed treatments for fall insect protection, and sulfonylurea herbicide carryover tolerance are also available. For more information about variety characteristics, see Table 3 or university variety trial results. Check with local extension offices or your local seed dealer for adapted varieties and seed availability in your area.

A regional breeding program has existed at Kansas State University since 1991. To date, four varieties adapted to the region have been released. Two of these varieties are available from multiple certified seed growers in the region and Kansas Foundation Seeds, Manhattan, Kansas. In 2005, the regional breeding program became coordinated by both Kansas State University and Oklahoma State University through a cooperative agreement. Additionally, several private companies are developing and testing varieties for potential use in the region.

With more interest in winter canola production in the region, the number of adapted varieties will likely increase. A strong regional and national performance testing system was established in 1982 to evaluate new varieties and those varieties already on the market. This system allows for the dissemination of data necessary to ensure the best-adapted varieties are commercially available. The National Winter Canola Variety Trial is grown at more than 60 locations throughout the United States and the results assist farmers in variety selection. A new variety must only be considered after it demonstrates its adaptability over multiple locations and years. Current experimental lines under consideration demonstrate enhanced levels of winter hardiness, yield potential, and agronomic traits improving their suitability to the region. Additional traits being incorporated into adapted varieties include the Clearfield® herbicide resistance system, even maturity, early flowering, heat tolerance at flowering, reduced height, aphid feeding tolerance, low pH tolerance, and pod shattering resistance. Improved varieties should be available on a regular basis for both spring and winter production.

Crop Growth and Development

The growth and development of the winter canola plant is divided into easily recognizable growth stages (Photos 4 – 9). The length of each growth stage is influenced by temperature, moisture, light, nutrition, and variety. Growers with an understanding of how a canola plant develops and how it is affected by production practices can make more effective management decisions.

Preemergence (Germination)

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.

Seedling

The seedling typically emerges 4 to 10 days after planting and develops a short stem. The cotyledons at the top of the hypocotyl expand, turn green, and provide nourishment to the plant (Photo 4). The roots also continue to develop. Unlike wheat, whose growing point is protected beneath the soil during early development, the growing point of canola

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	Field bioassay required
Ally Extra	Wheat	Field bioassay required
Amber	Wheat	Field bioassay required
Atrazine	Corn/Sorghum	2nd fall following application
Autumn	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	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
Priority	Corn	15 months
PowerFlex	Wheat	9 months
Python	Corn	26 months
Rave	Wheat	Field bioassay required
Require Q	Corn	10 months
Resolve	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] *Rotational interval depends on geography.*

is above the soil between the two cotyledons. Thus, canola seedlings are more susceptible than cereals to environmental hazards and insect damage at this stage.

Rosette

A seedling develops its first true leaves 4 to 8 days after emergence. The plant establishes a rosette with larger, older leaves at the base and smaller, newer leaves at the center. The root system continues to develop, with secondary roots growing from the taproot. The stem length remains unchanged as its thickness increases (Photo 5).

Rapid establishment of a leaf canopy is important in the development of a canola crop. The larger and more abundant the leaves, the greater their ability to capture sunlight, produce nutrients for growth, and develop a crown and root system. 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. 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 considerably smaller than this have reduced potential to survive. Plants considerably larger require more soil moisture and succumb to moisture stress. Too much fall growth causes stem elongation and the plant will die. Additional stress factors such as excessive insect feeding and heaving from the soil may reduce survival. Spring types form considerably smaller rosettes than winter types because they do not overwinter.

Response to Cold Temperatures of Winter Types

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. Depending on the field and variety, all or some parts of the field will turn a shade of purple or red. Photos 10 and 11 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 die, the plants will resume rapid growth.

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. As rising temperatures and lengthening daylight initiate bud formation, a cluster of flower buds becomes visible at the center of the rosette and rises as the stem rapidly bolts (Photo 6) or lengthens. Leaves attached to the main stem unfold, and the

Table 3. *Commercially available winter canola cultivars.*

Name	Brand/ Distributor[1]	Plant Type[2]	Release Date	Relative Maturity[3]	Herbicide Resistant[4]	Sulfonylurea Residual Tolerant	Low pH Tolerant
Baldur	Croplan Genetics	HYB	2004	E/M	–	–	–
HyClass 107W	Croplan Genetics	OP	2007	M/F	RR	–	–
HyClass 110W	Croplan Genetics	OP	2008	E	RR	–	–
HyClass 115W	Croplan Genetics	OP	2008	E	RR	Yes	–
HyClass 154W	Croplan Genetics	HYB	2008	F	RR	–	–
Kronos	Croplan Genetics	HYB	2003	M	–	–	–
Virginia	Croplan Genetics	OP	2003	E/M	–	–	–
DKW13-62	DEKALB	OP	2003	F	RR	–	–
DKW13-69	DEKALB	OP	2007	F	RR	–	–
DKW13-86	DEKALB	OP	2003	M	RR	–	–
DKW41-10	DEKALB	OP	2008	E	RR	–	Yes
DKW45-10	DEKALB	OP	2008	M	RR	–	–
DKW46-15	DEKALB	OP	2008	M	RR	Yes	–
DKW47-15	DEKALB	OP	2008	F	RR	Yes	–
Dimension	DL Seeds Inc.	HYB	2008	E	–	–	–
Flash	DL Seeds Inc.	HYB	2007	F	–	–	–
Hornet	DL Seeds Inc.	HYB	2007	M	–	–	–
Rally	DL Seeds Inc.	HYB	2007	M	–	–	–
Safran	DL Seeds Inc.	HYB	2008	M	–	–	–
Sitro	DL Seeds Inc.	HYB	2007	E	–	–	–
Sumner	Kansas State	OP	2003	E	–	Yes	–
Wichita	Kansas State	OP	1999	M	–	–	–
Forza	Momont, France	OP	2007	M	–	–	–
Kadore	Momont, France	OP	2007	F	–	–	–
Hybrigold	Momont, France	HYB	2008	E	–	–	–
Hybristar	Momont, France	HYB	2006	E	–	–	–
Hybrisurf	Momont, France	HYB	2008	M	–	–	–
Satori	Momont, France	OP	2006	M	–	–	–

[1]*For Croplan, DEKALB, and Kansas State cultivars, contact your local seed dealer for details. DL Seeds and Momont cultivars are distributed by Miles Enterprises, Owensboro, KY.*

[2]*HYB=hybrid, OP=open pollinated*

[3]*E=early, M=medium, F=full*

[4]*RR=Roundup Ready*

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 becomes adequate.

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 bud on the main stem, or raceme, and continues upward, with three to five or more flowers opening each day (Photo 7). Secondary branches begin flowering a few days later. Under favorable 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 one-half of the open flowers are developed into productive pods and maintained by the plant until harvest. When unfavorable conditions such as a late spring frost or drought cause abortion of flowers or pods, the plant recovers rapidly by developing buds that would have been aborted. The plant only maintains the number of pods it can support through photosynthesis under existing conditions.

Maturation and Ripening

Maturation begins as the last flowers fade from the main raceme. Flowering continues on secondary racemes for some time. 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 (Photo 8).

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 color changes, follows seed filling. The stems and pods turn yellow and progressively become brittle as they dry (Photo 9). The pod is divided into two halves by a membrane that runs its full length. 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.

Seeding

Small-grain equipment is used to plant canola, but a good seedbed is more critical for establishment than for small grains. 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 canola.

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 develops a crust easily. 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 prior. Preplant fertilizer and herbicide are generally applied before the final tillage operation of the seedbed. The last tillage operation should occur less than 1 week before planting to 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 September 1.

Several growers in the southern Great Plains have reported success with no-till management practices while others have been less successful. Equipment providing good seed-to-soil contact and uniform planting depth is important. Some difficulties in maintaining a stand throughout the winter have been encountered when seed has been placed into the residue from the previous crop rather than planted into the soil. Also, when residue is heavy, the canola crown may develop on top of the residue rather than at the soil surface, which can lead to stand loss during the winter. Thus, removing residue from the seed-row may be very beneficial in obtaining a stand and ensuring its winter survival. Success has been achieved by baling or burning crop residue and then planting, or by using coulters on narrow-row planters. For no-till seeding, avoid compacted soil for optimum root development.

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. These planting dates are illustrated in Figure 1. Spring types are planted at similar times to oat planting in the High Plains (March into April). Seeding dates also may be defined by the availability of crop insurance in your area. Recent observations indicate that there may be better winter survival when planting earlier in the seeding window rather than later.

Often, planting too early results in large plants using excessive amounts of water and nutrients during fall growth. This may cause water stress, which often decreases winter survival. Planting too late results in small plants that have insufficient reserves to maximize winter survival. Thus, winter survival often decreases with either earlier or later than optimum planting. Planting date also affects canopy cover and weed control. Planting date may affect maturity when growing spring canola.

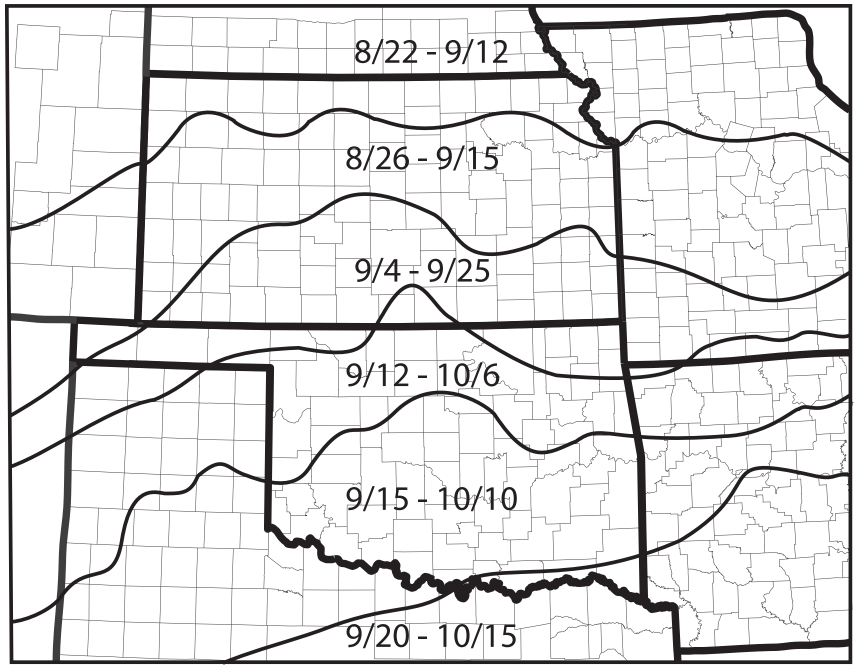
Seeding Rate

Canola is adapted to a wide range of plant populations. 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. Hybrid canola, having larger seed size and more branching potential, may be planted at a reduced rate of 3.5 pounds per acre.

A poorly established crop should be carefully evaluated in the early spring before destroying it. 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 increases weed problems because they 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 planting rates produce smaller, less vigorous plants prone to winterkill.

Canola seed of average size has approximately 115,000 seeds per pound. Hybrid canola seed is about 30 percent larger than non-hybrid seeds. With average size seed, 1 pound per acre equals approximately 1.6 seeds per foot of row in 7.5-inch rows. The percent emergence varies with seed quality, soil conditions, and seeding method. The seed tag will display the seed count per pound to help determine the appropriate seeding rate. Average seeding rate for the Great Plains with good seedbed preparation at the optimum planting date is 5 pounds per acre. 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 higher rates than dryland production areas. Drills should be calibrated to ensure desired seeding rates. With rates lower than other crops, canola seeding may require a speed reduction kit, especially on older drills, or every other hole may be plugged.

Figure 1. *Canola planting dates for the southern Great Plains.*



Seeding Depth and Row Spacing

Because canola seeds are very small, careful placement at a relatively shallow depth is advised. Best germination and emergence usually occur from seeding depths of ½ to 1 inch when soil moisture is adequate. Canola can emerge from greater depths, but seeding deeper than 1 inch delays emergence, reduces seedling vigor, and delays fall crop development. Canola experiences difficulty forcing its way through thick soil covers or crusted soil. If the seedbed dries too fast, emergence from shallow depths is not uniform. 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 farmers prefer the stale seedbed approach. A firm seedbed does not mean pressing the seed furrow hard with a packing wheel. Drill-type press wheels should have just enough pressure to lightly firm the seed and close the furrow. Generally, a light row packing in firm soil is preferred. In no-till, it is best to place seed approximately 1 inch deep.

The 6- to 15-inch row spacing available on most commercial grain drills is acceptable for canola. Row spacing up to 15 inches has minimal impact on final yield. Narrower spacing provides quicker canopy closure, reduces weed competition, and lessens wind shattering before harvest.

Fertility Management

Southern Great Plains

Soil fertility and fertilizer management play a major role in the winter survival, yield, and 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 profile 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 and analyzed for pH and lime requirement, plant-available phosphorus, and potassium. In some cases, soil organic matter and zinc tests may improve the overall fertilizer recommendation package. Profile samples for nitrate-N should be taken to a depth of 2 feet (nitrate-N is included in the 0- to 6-inch sample in some labs; therefore, a 6- to 24-inch sample should be collected for subsoil nitrogen assessment). A profile sulfur test also can be helpful in some parts of the southern plains.

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 growers apply all the nitrogen for wheat in late summer before planting, only a third of the total nitrogen for canola (roughly 30 to 50 pounds per acre) should be applied before planting. In addition, apply all phosphorus, potassium, sulfur, and other soil amendments before the final tillage operation.

Preplant Fertilizer and Lime Applications for the Southern Great Plains

Lime Recommendations

Canola has similar pH requirements to wheat. 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 or above, depending on what other crops are grown in rotation. The Shoemaker, McLean, and Pratt (SMP) Buffer is used to estimate lime requirement across the region. The specific lime recommendations using the buffer pH are given in Table 4. These recommendations are based on a 6-inch sample depth and assume incorporation with tillage. In no-till production systems, the lime will only react with the surface 2 to 3 inches of soil, so only one-third to one-half the normal recommended rate should be applied. As with wheat, variety selection 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 put on 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 phosphorous fertilizer recommendations for use with canola in Kansas are given in Table 5, and general potassium recommendations are given in Table 6. These tables give general recommendations over a range of soil test values. For more precise information using your soil tests results, both the Kansas State University Agronomy Department and the Oklahoma State University Department of Plant and Soil Sciences have downloadable fertilizer recommendation programs available at their soil testing lab Web sites. *www.soiltesting.okstate.edu, www.agronomy.ksu.edu/soiltesting*

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.

Table 4. *Lime recommendations using the SMP Buffer pH for two target pH levels in pounds Effective Calcium Carbonate (ECC) per acre.*

Buffer pH	Target pH = 6.8 (lbs ECC/A)*	Target pH = 6.0 (lbs ECC/A)*
7.2	750	375
7.0	1,750	875
6.8	3,000	1,500
6.6	4,500	2,250
6.4	6,250	3,125
6.2	8,250	4,125
6.0	10,250**	5,125
5.8	12,500**	6,250
5.6	15,250**	7,625

**When using a continuous no-till production system, apply only one third to one half the recommended rate.*
***When lime recommendations exceed 10,000 lbs ECC/A, we suggest applying one-half rate, incorporate, and retest in 12 to 18 months.*

Table 5. *General phosphorous recommendations for winter canola based on the Mehlich 3 soil test on the southern Great Plains.*

Soil test P level (ppm)	Pounds P_2O_5 recommended per acre
0-5	70
6-10	50
11-15	30
16-20	20
21-30	10
31+	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. The consequences of low soil sulfur levels are very serious. A composite soil test for sulfur may not represent sulfur fertility variation across the field. The current sulfur soil test tends to overestimate available sulfate-sulfur, and field variability can be large. Growers should consider applying sulfur regardless of soil test levels. Canola growers should consider using a sulfate or thio-sulfate form of sulfur.

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 is available for that 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 formula:

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

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

Table 7 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 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 parts per million) can result in excess vegetation and reduce winter hardiness. Therefore, it is recommended that only one-third of the total season's nitrogen be applied preplant (roughly 30 to 50 pounds per acre), with the balance being top-dressed in the late winter.

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.

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 winter. A total of 40 to 80 pounds of nitrogen fertilizer plus profile nitrate available in the fall appears to improve winter survival.

Table 6. *General potassium recommendations based on the Mehlich 3 or ammonium acetate soil tests on the southern Great Plains.*

Soil Test K (ppm)	Pounds K_2O recommended per acre
<40	60
41-60	50
61-100	30
101-125	20
>125	0

Table 7. *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

Fertilizer Applications with the Drill

Like most oilseeds, canola is much more sensitive to salt and ammonia injury than wheat or corn. Therefore, growers should be extremely cautious when band applying fertilizers to avoid seed-fertilizer contact. 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 to avoid seed-fertilizer contact.

Late-Winter Topdressing

Canola responds to nitrogen fertilizer applied in late winter while the plants are still dormant, much like wheat. The majority (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 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 are preferred.

Canola Fertility Management for 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 to 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 8.

For soils with 1 percent organic matter, add 15 pounds nitrogen for each yield and nitrate level above and 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 9 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 N + K + S should be used with the seed on 12-inch spacing. For narrower row spacing, proportionately higher levels can be used (e.g., 20 pounds N + K + S 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 10). Canola takes up large amounts of potassium, and potassium fertilizer should be applied before planting.

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.

Table 8. *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 9. *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 10. *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

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 is commonly grown in rotation with wheat, sorghum, and 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. For current weed control recommendations see Table 18 on page 23.

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.

Planting most canola varieties following the application of residual sulfonylurea and imidazolinone herbicides should be avoided. 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, atrazine, Autumn, Beacon, Equip, Hornet, Peak, Permit, Priority, Python, RequireQ, Resolve, Spirit, Steadfast, or Yukon; or the cotton herbicides Envoke and Staple (see also Table 2). Canola plant-back restrictions may not always be listed on a 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.

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.

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*), cheatgrass (*Bromus secalinus*), and downy bromegrass (*Bromus tectorum*) (Photos 13 – 15). They do not control mustards or volunteer cereals.

For control of cool-season grasses, apply quizalofop (Assure II), sethoxydim (Poast), or clethodim (Select 2 EC and generics) in the fall before the target weeds reach dormancy or in the spring after the weeds begin regrowth. Good control is expected on grassy species such as Japanese brome (*Bromus japonicus*), cheat, downy brome, rescuegrass (*Bromus catharticus*), feral rye (*Secale cereale*), jointed goatgrass (*Aegilops cylindrical*), Italian ryegrass (*Lolium multiflorum*), wild oat (*Avena spp.*), and volunteer wheat (*Triticum aestivum*) if label directions are followed (Photos 15 – 21). Do not graze canola treated with Sonalan, Select 2 EC, clethodim generics, or Assure II. Refer to the product labels to determine whether your target species is listed on the label.

Winter canola varieties with the Roundup Ready® (glyphosate tolerance) trait are currently available in the Great Plains region and more varieties will be available within the next few years. This system provides nonselective control of the winter annual grasses listed above and broadleaf weeds including blue mustard (*Chorispora tenella*), bushy wallflower (*Erysimum repandum*), wild mustard (*Brassica kaber*), tumble mustard (*Sisymbrium altissimum*), tansy mustard (*Descurainia pinnata)*, flixweed (*Descurainia sophia*), field pennycress (*Thlaspi arvense*), and shepherdspurse (*Capsella bursa-pastoris*) (Photos 22 – 29). Apply 1 to 1.5 pints of glyphosate per acre to Roundup-Ready® canola from emergence through the 6-leaf stage of growth. Experimental lines 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.

The most common mistake with canola weed control is waiting too long in the fall to control weeds. If volunteer wheat or grassy weeds are present, a herbicide should be applied by 4 to 6 weeks after seeding. Waiting for additional rain to germinate more weeds is usually a serious mistake.

Response to Field Conditions and Herbicide Symptoms

Many factors can cause differences in the appearance of canola plants that are not usually reason for major concern. Differences in size and color may be caused by soil type, fertility, previous crop, variety of canola planted, and winter weather. Nonetheless, growers should be alert to symptoms of low pH effects (photo 2), nutrient deficiencies (photos 86 – 96), and diseases (photos 43 – 53).

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. Also remember that wheat is very susceptible to many herbicides applied to canola. It is a good strategy to inform local custom applicators and neighbors that you are growing canola at a given site, and remind them that it is very susceptible to drift from herbicides applied to wheat or to pastures and rangeland.

Herbicide residue and drift are more common in areas with inexperienced growers and pesticide applicators (Photos 30 – 42). Sulfonylurea herbicides such as Finesse, Ally, Osprey, Olympus, PowerMax, and Amber can severely injure canola. As a general rule, sulfonylurea herbicides reside in the soil longer if organic matter is low and pH is greater than 7.5. Herbicide carryover also can be affected by soil texture, drought, temperature, and field history. Glyphosate herbicides must not be applied to non-glyphosate resistant canola (Photo 31).

Photos 32 – 37 illustrate symptoms of herbicide residue carryover from previous crops. Symptoms include and are not limited to stunting, chlorosis, discoloration, malformed leaves, root pruning, and plant death. Damage from herbicide drift or tank contamination are generally from sulfonylurea herbicides and hormone products like 2,4-D, MCPA, dicamba, and picloram. Photos 38 and 39 illustrate typical sulfonylurea herbicide damage from drift or sprayer contamination. The symptoms are mainly chlorosis and stunting. Photos 40 – 42 show typical hormone damage from drift or sprayer contamination. In the field, symptoms appear about 10 days after exposure. Symptoms may include swelling above and within the crown, swelling and epinasty of the stems and severe epinasty on the main stem. Chlorosis will be noted in the leaves with time.

Volunteer Canola Control in Winter Wheat

Although canola has been reported as volunteer for several years, problems with volunteer canola are not common. The seed has little dormancy and typically germinates after summer rains and can be eliminated by tillage or in no-till by herbicides. Table 11 provides a general rating for herbicide effectiveness on volunteer canola. These ratings were based on research where herbicides were applied either in the fall or spring to actively growing canola. All postemergence herbicides were applied with recommended adjuvants. These ratings are based on 1 or 2 years of research. Volunteer canola will compete with the succeeding crop and may affect yield, depending on the volunteer density. Steps should be taken during swathing and combining operations to minimize canola seed losses. For no-till small grains, consider adding a labeled herbicide to the glyphosate burndown application to control emerged glyphosate-resistant volunteer canola. Volunteer canola that emerges before or with the crop may be 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. There are some herbicides that provide excellent control of small volunteers, but provide poor control of bolting canola. 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.

Table 11. *Volunteer canola control in winter wheat.*

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

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

Diseases

Canola is a member of the mustard family (*Brassicaceae*, formerly *Cruciferae*), which includes such common weeds as mustards, pepperweed (*Lepidium virginicum*), and shepherdspurse. Diseases that affect these weeds may also affect canola. Diseases attack canola at all stages of development. They can be soilborne, seedborne, or airborne and spread from infected crop residues. The occurrence of major diseases in the Great Plains is low, but 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. 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 blackleg fungus survives 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. On newly infected plants, a second spore type, called conidia, are released from small, black, pimple-like structures known as pycnidia and are responsible for infecting neighboring plants and seed pods. Blackleg is 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 (Photo 43) 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 (Photo 44) 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 45). 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 2.

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 blackleg including Helix Lite, Helix XTra (difenoconazole + metalaxyl + fludioxonil + thiamethoxam), Maxim (fludioxonil), and Prosper (clothianidin + thiram + carboxin + metalaxyl). Quadris (azoxystrobin) is a foliar fungicide registered for blackleg control in the United States.

If blackleg is observed in a field, deep-plow the stubble before canola is planted on other nearby fields. Use minimum tillage or no-till in subsequent crops to avoid bringing infected stubble back to the surface. Till blackleg-infested fields last and then thoroughly clean equipment before using in other fields where blackleg does not exist. Blackleg spores can persist in soil up to 5 years. Resistant varieties are available and most varieties developed in the Great Plains possess good resistance.

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. A wide range of field crop hosts exists including dry beans, sunflowers, and soybeans. Sclerotinia stem rot is usually more serious in crops like dry beans than canola, yet 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, but 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. If possible, time irrigations to keep the soil surface dry during flowering in order to minimize disease risk.

The first noticeable symptom of Sclerotinia stem rot is the presence of prematurely ripened plants (Photo 46). 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 47). Hard black structures (Photo 48) 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 49). 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 Sclerotinia cycle is shown in Figure 3.

Prevention is the best means of control. Once the disease is present in the soil, however, a 4-year rotation with non-susceptible crops should be used. Keep in mind that deeply buried sclerotia remain dormant in the soil 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. Foliar fungicide treatments can be effective, but timing is critical; make applications at the early- to mid-bloom stages. Endura (boscalid), Quadris (azoxystrobin), Ronilan (vinclozolin), and Topsin M (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 50 – 51). Often the spots are surrounded by a light green or yellow halo.

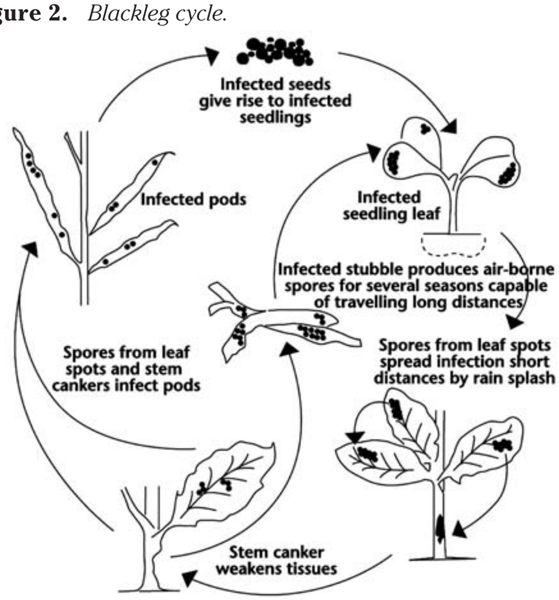
Alternaria survives in infested crop residue, on infested seed, and on some alternative weed hosts. Infested seed either rots in the soil or produces infected seedlings. Wind-blown spores germinate, penetrate plant tissues, and cause lesions within a few days. These lesions produce more spores, which 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, and controlling susceptible weeds and 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 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. Plant stems will be hollow and rotten when pulled from the ground. Oftentimes root maggots (*Delia* spp.) are present. The best management strategy is to plant a winter-hardy variety at the optimum planting date. Winter decline syndrome tends to be a problem in climates where rapid fluctuations in winter temperatures are common.

Figure 2. *Blackleg cycle.*



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 52). 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. The disease is favored by moderate temperature, high humidity, excessive nitrogen fertilization, and excessive canopy density. In some production areas, powdery mildew results in serious yield losses. However, it likely will remain a minor disease in most areas of the Great Plains.

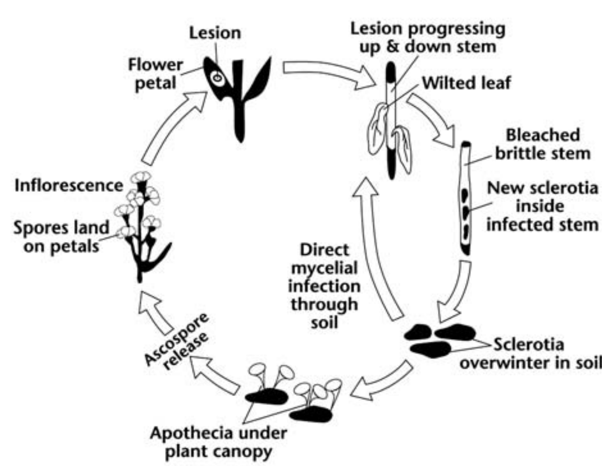
Black Rot

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 will likely remain insignificant to canola production 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

Figure 3. *Sclerotinia stem rot cycle.*



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 53). 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.

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

Several insect species can damage winter canola. Some insects reduce yields by defoliating plants or attacking buds or seedpods. Other insects carry plant pathogens such as aster yellows. Some insects exist on canola and mustards only, whereas some are found in other cole crops and still others have an even wider host range. Seedling canola is especially vulnerable to chewing insects, because plants will die if the aboveground portion is completely eaten. Damage caused by insects is more severe during periods of stress, especially drought. Canola pests can cause problems throughout the entire growing season (Table 12). Because canola is not produced extensively across the Great Plains, information on insect pest thresholds is somewhat limited. For current insect-control recommendations see Table 19 on page 25.

Insects known to attack canola are wireworms (various species), flea beetles *(Phyllotreta spp.)*, grasshoppers (various species), fall armyworm (*Spodoptera frugiperda*), beet armyworm *(Spodoptera exigua)*, army cutworm *(Euxoa auxiliaris)*, imported cabbageworm (*Pieris rapae)*, southern cabbage worm *(Pontia protodice),* cabbage looper *(Trichoplusia ni*), diamondback moth *(Plutella xylostella)*, cabbage aphid *(Brevicoryne brassicae)*, green peach aphid *(Myzus persicae),* turnip aphid (*Lipaphis erysimi),* Harlequin bug (*Murgantia histrionica),* false chinch bug *(Nysius raphanus),* cabbage seedpod weevil (*Ceutorhynchus assimilis),* red turnip beetle *(Entomoscelis americana),* thrips (various species), root maggot *(Delia spp.),* and lygus bugs *(Lygus spp.)* (Photos 54 – 79).

Several insecticides and seed treatments are registered for canola. Insecticides containing *Bacillus thuringiensis* (Dipel and other trade names), bifenthrin (Capture and several other trade names), 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.

If spraying of insect pests is necessary, select insecticides carefully and consider options that would protect pollinating insects as well as predatory insects. Cultural practices such as crop rotation, killing volunteer canola, spraying ditches and fencerows for wild mustard, and incorporating plant residue into the soil are important means of insect control. As the number of acres of canola increases 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.

Insects causing serious problems in the southern Great Plains over the past 10 years include flea beetles, grasshoppers, army cutworms, diamondback moth larvae, aphids, and root maggots. Generally, flea beetles are less of

Table 12. *Insect pest scouting calendar for 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	False Chinch Bug	False Chinch Bug
Turnip Aphid	Turnip Aphid	Turnip Aphid	Lygus Bug	Lygus Bug
Diamondback Moth Larvae	Diamondback Moth Larvae (plant crowns)	Diamondback Moth Larvae		Armyworm
Flea Beetle				Seed Pod Weevil
Grasshopper				Harlequin Bug

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. Plants withstand 50 percent damage to the cotyledons without suffering any loss of yield potential. However, if populations are high and feeding becomes excessive, stand reductions can occur. Overwintering flea beetles attack canola in the spring, but foliage is abundant and potential damage needs to be severe for treatment to be economical. Grasshoppers are a problem at seedling emergence. During years of high populations, grasshoppers migrate into emerging stands and devour the cotyledons. Damage is usually limited to the field margins. Canola is especially palatable to army cutworms. Treatment is necessary in years when army cutworm populations are high. Populations of four to five per square foot cause severe damage to stands.

Aphids have become the most important insect pest of canola in the southern Great Plains (Photos 65 – 68). The turnip and green peach aphids have been frequently observed to colonize fields during fall growth, survive mild winters, and increase to damaging levels during the early spring. Green peach and turnip aphids feed on the underside of canola leaves. Cabbage aphids colonize 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 are sometimes high enough to cause significant stand decline and reduce seed production. The frequency of fall aphids and their potential for damage clearly suggest that a seed treatment should be considered as an important preventative management approach. Seed treatments using clothianidin, imidacloprid, or thiamethoxam are effective at reducing fall aphid infestations, but will not prevent aphids from building up on spring growth and infesting flowering racemes in the spring. Scouting is the best method to ensure effectiveness of seed treatments during the fall and determining if treatment is necessary on emerging spring infestations. If populations are high from January through March, an insecticide treatment may be necessary. It is important to note that canola can recover from aphid infestations following timely insecticide applications.

Sampling for Green Peach or Turnip Aphids in Winter Canola

1. Walk diagonally across field and stop 10 times.
2. Check three plants at the 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 68).
5. Note other spots with dead or dying plants.

Cabbage Aphids in the Flower Cluster

During flowering, cabbage aphids reproduce on the stalk inside the cluster of flower buds making it difficult for ladybugs to penetrate this cluster and eat aphids. Pushing the flower cluster open with your fingers is often necessary to find these aphids. Damage to flower buds and flowers prevents pod set and can reduce yields severely. If these 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 scout your fields for these aphids several times during flowering.

Table 13. *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*

Action Thresholds

For every aphid per plant, 0.5 pound of seed yield is lost. Before flowering begins, canola can handle large numbers of aphids before a costly insecticide is justified. It is important to delay insecticide use until aphids approach economic levels because:

- Use of insecticides on very low populations will result in net dollar losses.
- Delaying the first insecticide application reduces the chance of needing a second or third application.
- To prevent economic losses, manage aphids when canola prices reach the levels in Table 13.

Diamondback moth larvae may cause serious problems in the southern Great Plains (Photo 63). Scouting canola fields for diamondback moth larvae should begin following emergence. In the fall, diamondback moth larvae and aphids arrive earlier if a seed treatment was not used. Diamondback moth larvae often attack larger canola that was seeded early. These larvae resemble green loopers and are foliage feeders. If they are present, shot holes will be observed in the leaves (Photo 80). If they are eating significant amounts of foliage, an insecticidal control should be considered.

Diamondback moth larvae will overwinter and feed in the crown of canola plants. In a cold winter, this may be the only habitat available for small larvae. If infestations in the crown are high, they can be very destructive and stand loss may occur before spring. Larval infestations of the crown can easily be mistaken for winterkill. Malformed leaves emerging from the crown due to larval feeding also may be noted. To scout for the larvae, pull up a few plants and tap the crowns on a piece of white paper.

Root maggots can be a problem on canola during cold, wet growing seasons. Plants infested with maggots may easily lodge, have feeding damage inside the stem at the soil level, and 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 with higher seeding rates appears to help prevent economic damage. However, because of long periods of adult flight, insecticide applications in the spring are not economical. Effective control of related mustards removes potential plant hosts that could contribute to increasing maggot populations.

Several other insects occur in the area, but are often not abundant enough to cause serious problems. Wireworms are a potential pest as they are with many other crops, and can be managed with seed treatments if problems are anticipated before planting. Fall armyworms and beet armyworms can attack fall-seeded canola; watch for larvae and treat if stands are threatened. The cabbage seedpod weevil is a severe pest throughout Europe and the northwestern United States. The economic threshold established in these regions is two weevils per plant at flowering. Cabbage seedpod weevil is attracted to the yellow color of canola flowers and attacks young seedpods during and after bloom. The cabbage seedpod weevil lays eggs inside pods, and the developing grubs feed on the maturing seeds. High infestations cause losses of 20 to 30 percent.

Cabbage worms and alfalfa loopers (*Autographa californica*) defoliate canola plants in the spring and summer. Economic thresholds are not established, but damage is usually minor and yield loss minimal if the plants are healthy and growing vigorously.

Harlequin bugs are occasionally abundant in canola fields at harvest, but thresholds are not well established.

False chinch bugs can occur in large numbers during mild, dry winters. Research from Colorado shows that severe damage can occur if false chinch bugs infest racemes during bloom and early pod fill. Based on this work, it is suggested that fields should be treated with a registered insecticide if five to 10 false chinch bugs occur on flowering racemes, and if 10 to 20 false chinch bugs occur on racemes during early pod set. Fall infestations of false chinch bugs could cause stand losses. False chinch bugs are common in ripe fields of canola, but damage rarely occurs.

Lygus bugs feed and lay eggs on canola during budding. Damage includes flower abortion and poor seed set with small, shriveled seeds. Two generations per year are possible in the southern Great Plains and one generation per year in the northern Great Plains.

Bird damage can severely reduce yields; areas close to large flocks should be avoided.

Table 14. *Canola forage feed values compared to wheat and rye forage.*

	Protein (%)	NDF (%)	NEM (Mcal/ lb)	TDN (%)	RFV (%)
Wheat	36	29	0.8	71	225
Rye	33	31	0.8	71	217
Canola	23	17	0.92	80	414

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

Grazing

For centuries, rapeseed was used as high-quality, annual forage in Europe. Canola's potential as a dual-purpose forage/seed crop for use in the Great Plains is not well defined. Early research shows that grazing canola can reduce seed yield. For that reason, grazing is not recommended where the production objective is to produce canola seed.

Different canola cultivars produce varying amounts of fall forage for grazing. Canola is slightly lower in protein, lower in fiber, and higher in energy than wheat (Table 14). No more than 75 percent of the ration should be canola with the other 25 percent consisting of a lower quality, high fiber hay. Nutritionists recommend that canola forage should be treated as a concentrate rather than a forage crop. Since canola is relatively low in fiber, producers should exercise caution when introducing cattle to canola pasture and may want to consider a bloat preventative. Cattle should be full, near a source of fiber, and closely monitored when placed on canola pasture.

Producers in the region report cattle develop a taste for canola after a few days and noticeably devour the crop before moving to new forage. Other producers notice cattle are not interested in the crop until after a hard freeze. To obtain a better use of the crop, graze canola with calves 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.

Management guidelines for canola as a dual-purpose crop are limited at this time. 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 or 8 inches tall. Adjust stocking rate so new growth is consumed. Canola grows vigorously at this stage. Remove cattle when half of the original forage remains. Canola grazing can be viewed as opportunistic. The availability and duration of canola forage is more weather dependent than for winter cereals. Therefore, producers should not rely on canola as the primary part of their grazing program.

Harvest

Canola can be either swathed and then harvested or direct combined. Whether to swath or direct combine is a management decision because both can be done successfully. Swathing is generally recommended for winter canola if harvest cannot be completed in a timely manner. Direct combining requires no additional equipment for wheat growers. Harvesting canola is a slower process than harvesting wheat. Ripe canola should be harvested immediately as preharvest shattering happens frequently. Equipment should be ready to combine canola just as soon as the crop is ready and it should be harvested before wheat, otherwise crop losses likely 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. Holes in the combine or trucks should be plugged with tape or caulk to ensure that the seed is not lost.

Direct Combining

Direct combining is generally recommended for the southern Great Plains because dry-down is accelerated by high air temperatures at ripening. Ideally, canola should be harvested when the average seed moisture is 8 to 10 percent and no green pods are visible. However, canola is an indeterminate crop and retains a few immature 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 the back. Waiting for smaller seed pods to mature will result in larger, higher yielding seed pods to shatter and reduce yield potential. Harvesting at slightly higher moisture content (10 to 15 percent) and then drying down in a bin may help reduce the effects of pod shatter. Check the grain in the grain tank to ensure there is little to no green seed.

Ripe standing winter canola is easy to thrash. Therefore, after first setting the combine, try opening the concaves more, as this reduces grinding of stalks. This will allow more material through, and by not grinding the green stalks, the moisture content of the canola seed will be lower. Keep an eye on what is coming out the back. Do not be concerned if you see a few green pods.

Canola seed is very difficult to see once it falls onto the ground. 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.

Advantages to direct combining

- Best opportunity to deliver No. 1 quality 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 with either the grower's combine or by custom cutters.
- No swathing equipment or pickup attachments for combines required.
- Best method for stands of canola that are tall, heavy, "laced" together, or lodged.
- Avoids risk of improperly laying (twisting or bunching) the crop on the ground by swathing.
- Decreased risk of diseases from poor drying and maturing that can occur when canola is lying in a windrow.
- Thicker, more productive crops will mature evenly and are easier to direct combine.

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.

General settings for conventional combines

- In general, the ground speed of the combining operation is slower than wheat.
- Harvest canola immediately below the seedpods to avoid excess trash and green stems moving through the combine and slowing harvest (Photo 81).
- The reel should be set high and as far back over the grain table as possible.
- Reel speed should be the same as the 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.
- Concave clearances - ¾ inch in the front and ⅛ to ¼ inch in the rear. Remember, canola is easy to thresh and you don't want to grind the stems any more than necessary. Grinding the stems can increase seed moisture. Increase concave clearance until seed is not threshed from pods.
- 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.
- Top sieve/chaffer set at ¼ to ⅜ inch for proper separation.
- Lower cleaning sieve set at ⅛ to ¼ inch.
- For rotary combines, use preset settings from the operator's manual. Most settings can be adjusted from the cab.

Swathing

Swathing reduces the possibility of seed losses from wind and hail. If swathing is the preferred method of harvest, it is important that the plant be at the proper stage of maturity. The best time to swath for optimum canola seed yield and quality is when average seed color change on the main stem is 40 to 60 percent and the seed contains 30 to 40 percent moisture. But canola can be swathed at 30 to 40 percent seed color change without sacrificing significant yield or quality. This widens the “swathing window” for growers.

Swathing involves cutting and placing the crop in windrows directly on the cut stubble for approximately 7 to 10 days or until the seed moisture is 8 to 10 percent (Photo 82). At this time, the canola can be harvested with a pickup header. The windrow should not be placed on the ground. 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. The draper, belt-style of swather is superior to the auger style in reducing crop damage.

Regardless of the swather type used, the windrow must flow smoothly through the swather without bunching or twisting. Bunching and twisting leads to uneven drying and combining problems as well as increased 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. Swathing too early will result in green seed, lower oil content, and higher seed moisture. Swathing too late will result in excessive shattering.

Field staging for optimum time of swathing

Start inspecting fields approximately 7 to 10 days after flowering ends. Walk out and sample five to 10 plants, examining pods on the main stem only. Seeds in pods on the bottom third of the main stem mature first. Using the seed color change chart (Photo 85), take note of the seed color change percentage on the main stem. Only seeds with small patches of color (spotting) should be counted as color change. Most of the seeds in the top third should be firm and roll, as opposed to break or crush, when pressed between the forefinger and thumb. 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, especially with low plant populations. 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. The key to curing the crop in a windrow is moisture. The enzyme responsible for clearing the chlorophyll requires 14 days to change the seed to a mature color. Seed color is more important than the overall field, straw, or pod color when gauging the optimum time to swath.

Advantages of swathing canola:

- Harvest 8 to 10 days earlier.
- With earlier harvest comes an increased potential for double cropping.
- More management flexibility with large acreages since the timing of harvest is not as critical.
- Swathing can be done around the clock to assist with harvesting large acreages.
- Cutting weeds early allows a cleaner, drier sample and reduces the number of weed seeds that reach maturity.
- A properly swathed, tight windrow will withstand heavy rain storms and high winds.
- Uneven field maturity makes swathing a desirable option because of time management concerns with direct harvesting the canola.
- Swathing is advantageous if environmental conditions promoting shattering exist (hail, hard rain, high winds).

Disadvantages of swathing canola

- Research has shown a 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 will 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 accumulating its full complement of oil and protein will not accumulate any more after swathing. This reduces yield, oil, and protein content and increases green seed.
- The necessary machinery may not be readily available.
- Stands of canola that are tall, tangled, or lodged make it difficult to lay down an unbunched, smooth windrow.
- The amount of material in a heavy crop to be forced through the throat of the swather may be a problem.
- Light or fluffy windrows can be lifted and blown by the wind. Swath rollers that lightly push the windrow down into the standing stalks reduce the risk of blowing (Photo 83).

Combining swathed canola

Canola is ready to combine when seed moisture has dropped under 10 percent. Under normal conditions, this is about 5 to 14 days after swathing. Most seeds will be mature with little or no green color. A moisture meter is essential to ensure correct harvest timing. If green seed is present due to rapid dry down and it is early in the harvest window, the windrows may be left longer to clear more green seed. Only a small percentage of green seeds will reduce the grade. By leaving the windrows to reduce green seed, you also run the risk that prolonged wet weather will delay combining and result in yield and quality losses.

Windrows are best picked up using a rubberized draper belt. These belt types have rubber or synthetic fingers and are preferred when harvesting canola as the gentle action helps to reduce shattering losses. The aluminum pick-up is more suited for bunched windrows. Direct cut headers require crop lifter attachments that are the width of the windrow that lift it into the header. The rest of the cutter bar may be covered to prevent or reduce the amount of second-cut stubble entering the combine.

Pushing

Pushing is a relatively new procedure for canola harvesting 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, and it is driven through the canola at a relatively high speed to force lodging (Photo 84). 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.

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 push the stalks over, but not break them off or rip them out of the ground. Vertical sickles are located at both ends of the pusher and directly in front of the tractor tire tracks. These are designed to ensure 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. The combine header must operate much closer to the ground than for standing canola. Harvesting is slower because more stalk material enters the combine. Growers should carefully scout fields for armyworms and other foliage feeders, and if they are present control them before pushing. A few growers in Oklahoma will be pushing their canola fields in 2009.

Desiccants

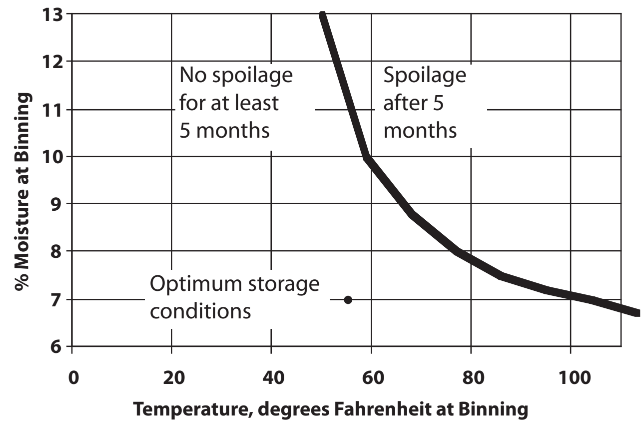
Generally, desiccants to facilitate drying are expensive and not necessary in the Great Plains because of high temperatures during dry-down. Desiccants are advantageous where plants are excessively lodged, weed infestations are heavy, maturity is not uniform, and the crop is not going to be swathed.

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.

Figure 4. *Safe and spoilage conditions for canola adapted from Mills (1996).*



Optimum Storage Conditions

Canola seed may be conditioned using aeration to reduce moisture and temperature to safe levels for long-term storage. Figure 4 shows the moisture content and temperature relationship for safe storage up to 5 months. Seed stored at conditions below and to the left of the curve showed no loss of quality for 5 months. While optimum storage conditions are 55 degrees Fahrenheit and 7 percent seed moisture, every reduction of 10 degrees Fahrenheit below 77 degrees Fahrenheit and 1 percent seed moisture below 9 percent will double the storage life. Storage below 6 percent seed moisture may result in seed damage during handling. The higher the storage temperature, the lower the moisture content must be for successful storage.

Cleaning Canola Seed

Broken seeds, pods, dirt, and other debris (also known as "dockage") make aeration more difficult by reducing airflow through the seed and can affect seed moisture content. Surface debris in storage also attracts insects. Insect development and activity cause excess heat and moisture, which encourage mold growth. 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 (ERH) is the point at which there is no exchange of moisture between the seed and the surrounding air. Mold begins to grow when the ERH is above 60 percent. Temperature and seed oil content determine the ERH of the stored canola. Canola varieties appropriate for the Great Plains average 40 percent oil content. Table 15 shows the ERH for canola with 40 percent seed oil content at various temperatures and seed moistures. The shaded area

Table 15. *Equivalent relative humidity and temperature influence on seed moisture content. (NDSU 2005).*

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

Table 16. *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.

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 ERH 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 15. 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 at temperatures greater than 77 degrees Fahrenheit for longer 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 16 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.

Insect and Mite Control

Insects can cause extensive damage in stored bulk products. Good management practices help prevent this damage. Always clean bins thoroughly prior to 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 Oklahoma stored products. 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.

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.

Budgets

Table 17 includes four sets of returns and cost estimates (enterprise budgets) for three canola production systems: wheat in a rotation with canola; Roundup Ready® canola in a rotation with wheat; and conventional canola in a rotation with wheat. The purpose of the budgets is to compare the economics of a canola-wheat-wheat rotation with continuous wheat. 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*.

Dryland wheat yields in the southern Great Plains vary considerably across years and across fields within years. The reported Oklahoma state average yield per harvested acre was 24 bushels in 2006, 28 bushels in 2007, and 37 bushels in 2008. The highest recorded Oklahoma state average wheat yield of 39 bushels per acre was most recently achieved in 2003. Data are not available to determine relative yields for wheat and canola across Oklahoma and Kansas regions and soil types. Results of long-term experiments of side-by-side comparisons of continuous wheat with a canola-wheat-wheat rotation are not available. However, growers who have several years of experience with both crops report anecdotal evidence of greater yields from wheat grown in a rotation with canola. Long-term experiments conducted in the Corn Belt have found that the expected yield of corn grown in a corn-soybean rotation exceeds the expected yield of continuous corn by 7.5 percent. The example budgets include a wheat yield of 40 bushels per acre for continuous wheat and 43 bushels per acre (a 7.5 percent increase) for wheat grown in a canola-wheat-wheat rotation. The budgeted yield of 1,800 pounds (36 bushels) per acre for canola is approximately 85 percent of the wheat yield.

The costs of nitrogen, harvest, and hauling are adjusted with yield. Costs for other inputs are held constant. 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 44 pounds per acre of monoammonium phosphate (MAP) (11-52-0), is estimated to be 60 pounds per acre [(40 bushels per acre × 2 pounds per bushel) – (44 pounds per acre × 0.11) – (15 pounds per acre carryover)]. This requirement can be met with 73 pounds per acre of anhydrous ammonia (82-0-0). Similarly, for an expected yield of 1,800 pounds per acre of canola and an expected requirement of 0.05 pounds of nitrogen per pound of canola, 44 pounds per acre of 11-52-0, and 15 pounds per acre carryover, 152 pounds of urea would be required per acre. 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. For this reason, top-dress urea rather than preplant anhydrous ammonia is budgeted for canola.

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 farmers 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. Farmers may contact their local county extension office for more information.

Table 17. *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	$5.40	40	216.00	43	232.20				
Canola	Lbs	$0.15					1,800	270.00	1,800	270.00
Gross Returns	acre			$216		$232		$270		$270
"Cash" Costs										
Wheat Seed	Bu	$15.00	1	15.00	1	15.00				
Canola Seed (RR + tech fee + treatment)	Lbs	$5.20					5	26.00		
Canola (Conventional)	Lbs	$2.00							5	10.00
Anhydrous Ammonia (82-0-0)	Lbs	$0.50	73	36.59	80	40.24				
Fertilizer Application	acre	$12.00	1	12.00	1	12.00				
Urea (46-0–0)	Lbs	$0.40					152	60.87	152	60.87
MAP (11-52-0)	Lbs	$0.60	44	26.40	44	26.40	44	26.40	44	26.40
Sulfur (0-0-0-90S)	Lbs	$0.36					6	2.16	6	2.16
Fertilizer Application	acre	$4.00	1	4.00	1	4.00	2	8.00	2	8.00
Herbicide (broadleaf)	acre	$5.00	1	5.00	1	5.00				
Herbicide (grass)	acre	$16.00	1	16.00	1	16.00				
Herbicide (e.g. Select®)	oz	$0.92							6	5.52
Herbicide (e.g. Assure II®)	oz	$1.15							8	9.20
Herbicide Additive (Crop Oil Concentrate)	ac	$1.00							2	2.00
Herbicide (Roundup PowerMax (glyphosate))	oz	$0.48					36	17.28		
Herbicide Additive (ams)	units	$0.125					2	0.25		
Herbicide Application	acre	$4.00	2	8.00	2	8.00	2	8.00	2	8.00
Seed Treatment (e.g. Prosper FX®)	acre	$6.00							1	6.00
Insecticide (e.g. dimethoate)	pint	$5.38	0.75	4.04	0.75	4.04				
Insecticide (e.g. Warrior®) Fall (1 of 3 yrs)	oz	$2.45					1	2.45	1	2.45
Insecticide (e.g. Warrior®) Spring	oz	$2.45					3	7.35	3	7.35
Foliar Fungicide (1 of 3 years)	acre	$12.50	0.33	4.13	0.33	4.13				
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	$14.00					1	14.00	1	14.00
Fuel	gallon	$3.00	4.92	14.76	4.92	14.76	4.92	14.76	4.92	14.76
Lube	acre			2.21		2.21		2.21		2.21
Repair	acre			7.12		7.12		7.12		7.32
Annual Operating Capital	$	$0.07	84.44	5.91	86.27	6.04	101.75	7.12	96.45	6.75
Wheat Custom Harvest & Haul										
Base Charge	acre	$23.00	1	23.00	1	23.00				
Excess for > 20 bu/a	bu	$0.23	20	4.60	23	5.29				
Hauling	bu	$0.23	40	9.20	43	9.89				
Canola Custom Harvest & Haul										
Swathing	acre	$12.00					1	12.00	1	12.00
Combining	acre	$16.00					1	16.00	1	16.00
Excess for > 20 bu/a	bu	$0.24					16	3.84	16	3.84
Hauling	bu	$0.24					36	8.64	36	8.64
Total "Cash" Costs	acre			$212		$217		$251		$240
Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management	acre			$4		$15		$19		$30

Table 18. *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 0.88 lb ai per gallon 5 to 12 fl oz/a	**Active Ingredients:** Quizalofop **Similar Products:** Matador **MOA: 1**	**POST.** Apply after crop and weed emergence but before grasses tiller.	**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.
Roundup Original Max 5.5 lb ai per gallon **Early preplant:** 11 to 44 fl oz/a **Post emergence:** 11 to 22 fl oz/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 varieties. Single Application**. One postemergence application of 11 to 16 fl oz/a can be applied no later than the 6 leaf stage. **Sequential Applications**. Two sequential applications of 11 to 22 fl oz/a, with a 60 day interval between applications, can be applied.	**Apply POST only in Roundup Ready Canola varieties. Do not** apply more than 44 fl oz/a of glyphosate during a growing season; **do not** apply more than 44 fl oz/a during EPP burndown or Pre-plant applications and no more than 22 fl oz/a over the top of Roundup Ready canola from emergence to the 6-leaf 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 6-leaf stage. Allow at least 60 days between last glyphosate application and canola harvest.
Select Max 0.97 lb ai per gallon 9 to 12 fl oz/a	**Active Ingredient:** Clethodim **Similar Products:** Arrow Envoy Volunteer 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 wheat 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. Including liquid fertilizer with the application is **NOT** recommended. **Do not** apply under conditions of drought stress. **Do not** graze treated fields or feed treated forage or hay. **Do not** apply within 70 days of harvest. **Do not** plant any crop for 30 days after application unless registered for use in that crop.

Table 18. *Continued on page 24*

Table 18. *Canola weed control suggestions. Continued from Page 23*

Trade Name, Formulation, and Application Rate	Active Ingredient(s), Similar Products, and MOA Group	Application Timing(s), EPP-early preplant, PPI-preplant incorporated, PRE-preemergence, or POST-postemergence	Special Instructions and Remarks
Sonalan HFP 3 lb ai per gallon 1.5 pt/a - Coarse Soil 2 pt/a - Medium 2.5 pt/a - Fine Soil	**Active Ingredients:** Ethalfluralin **Similar Products:** Sonalan 10G Trust Herbicide **MOA: 3**	**PPI.** To soil surface prior to 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:** Treflan TR-10 Trifluralin HF Trust 10G Trust 4EC Trust Herbicide **MOA: 3**	**PPI**. To soil surface prior to 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 19. *Management of insect and mite pests in canola. Read and follow all label directions before product use.*

	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 (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 of aphids. ***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. Evident from January through March. ***Damage:*** Cuts plants at soil line and clips opened leaves, can kill plants if it enters the crown. ***Threshold:*** Four to five 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 can reduce seedling stand and chew conspicuous, irregular-shaped holes in leaves. ***Threshold:*** Seedling, treat when scouting indicates one or more per row-foot. Treat when defoliation becomes severe, and larvae are present.	Azadirachtin (20B)	Apply per label	No PHI for harvest.
		B. thuringiensis (11B1,2)	Apply per label	No PHI for harvest.
		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 19. *Continued on page 26*

Table 19. *Management of insect and mite pests in canola. Continued from page 25*

	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.
		B. thuringiensis (11B1, 2)	Apply per label	No PHI for harvest.
		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. Wriggle rapidly when disturbed. ***Damage:*** Larvae feed on all plant parts, preferring the undersides of older leaves. ***Threshold:*** No threshold has been established.	Azadirachtin (20B)	Apply per label	No PHI for harvest (Aza-direct, Ecozin).
		B. thuringiensis (11B1, 2)	Apply per label	No PHI for harvest (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).
False chinch bug	Adults ⅛ inch long, dirty gray, with brown or black markings, piercing mouthparts. ***Damage:*** Feed in groups. Large numbers may cause wilting of heads or small plants. ***Threshold:*** 140 or more per head. ***Flowering:*** Treat when there is an *average* of five to 10 per head. ***Early seed pod:*** Treat when there is an *average* of 10 to 20 per head.	Azadirachtin (20B)	Apply per label	No PHI for harvest.
		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 19. *Continued on page 27*

Table 19. *Management of insect and mite pests in canola. Continued from page 26*

Pest	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.
		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
		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 19. *Continued on page 28*

Table 19. *Management of insect and mite pests in canola.* *Continued from page 27*

	Pest, Damage, and Treatment Threshold	Insecticide Formulation and (MOA Group)	Rate of Product per Acre	Comments
Lygus bug	Several species. Generally oval, about ¼ inch long, brown with some yellow or reddish markings. ***Damage:*** Feed on developing seeds, flowers, and leaves. Feed on buds. Thresholds are for infestations before or during petal fall. ***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 (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, seedling. Cause stand loss. ***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.*

Pre-harvest 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[r] 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[r] 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, Oklahoma Cooperative Extension Service

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Insect Pest Identification and Control Photos

(see pages 14 – 16 for more information)

Photo 54. *Wireworm.*

Photo 55. *Flea beetle.*

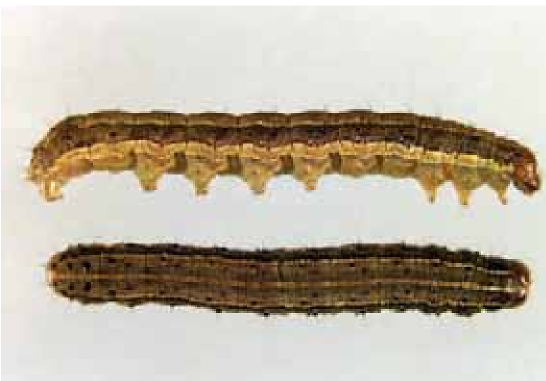

Photo 56. *Fall armyworm.*

Photo 57. *Beet armyworm.*

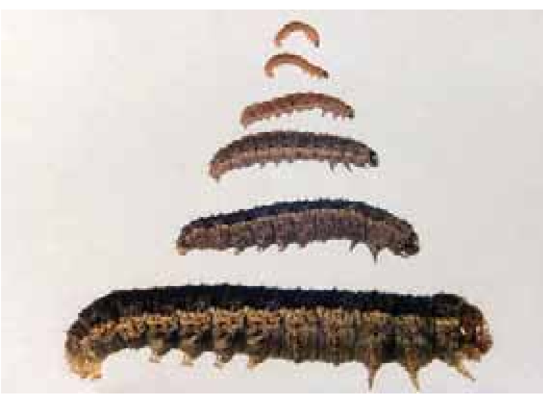

Photo 58. *Army cutworm.*

Photo 59. *Imported cabbage worm adult.*

Photo 60. *Imported cabbage worm larva.*

Photo 61. *Southern cabbage worm.*

Insect Pest Identification and Control Photos *(Continued)*

Photo 62. *Cabbage looper.*

Photo 63. *Diamondback moth larva.*

Photo 64. *Diamondback moth adult.*

Photo 65. *Cabbage aphid.*

Photo 66. *Green peach aphid.*

Photo 67. *Turnip aphid.*

Photo 68. *Aphids on canola.*

Photo 69. *Harlequin bug.*

Photo 70. *False chinch bug.*

Photo 71. *False chinch bug on bud.*

Photo 72. *Cabbage seedpod weevil adult.*

Photo 73. *Cabbage seedpod weevil larva.*

Photo 74. *Red turnip beetle.*

Photo 75. *Thrips.*

Photo 76. *Cabbage root maggot.*

Photo 77. *Lygus bug.*

Insect Pest Identification and Control Photos *(Continued)*

Photo 78. *Aster leafhopper.*

Photo 79. *Alfalfa looper.*

Photo 80. *Diamondback moth larvae feeding damage.*

Harvest (see page 16 - 19 for descriptions)

Photo 81. *Direct harvest of ripe canola.*

Photo 82. *Swathed canola ready to harvest.*

Photo 83. *Swathing with roller attachment.*

Photo 84. *Pushing canola.*

Harvest *(Continued)*

Photo 85. *Seed color change guide for swathing canola.*

Nutrient Deficiencies

Photo 86. *Nitrogen deficiency.*

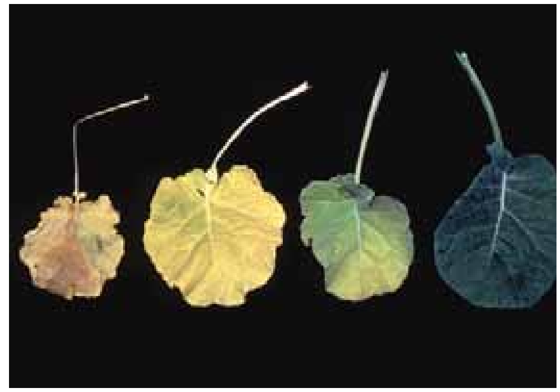

Photo 87. *Nitrogen deficient leaves, sufficient leaf on right.*

Photo 88. *Nitrogen deficient plant on left, sufficient on right.*

Photo 89. *Potassium deficiency.*

Photo 90. *Potassium deficient leaves.*

Photo 91. *Phosphorus deficiency.*

Photo 92. *Phosphorus deficient leaf.*

Photo 93. *Sulfur deficient plant.*

Nutrient Deficiencies *(Continued)*

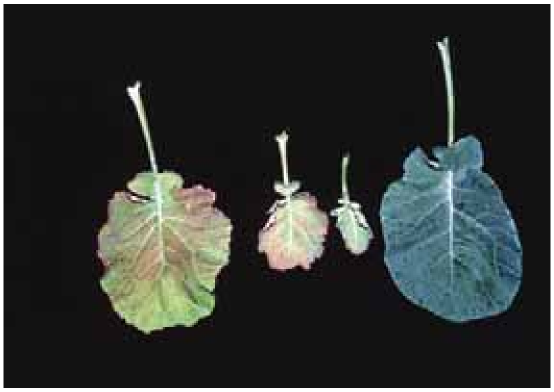

Photo 94. *Sulfur deficient leaves, sufficient leaf on right.*

Photo 95. *Sulfur, potassium, phosphorus, and nitrogen deficient pods, sufficient pod on the right.*

Photo 96. *Top left — sufficient; top right — nitrogen deficient; lower left — phosphorous deficient; lower right — potassium deficient.*

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

www.agronomy.ksu.edu/extension/DesktopDefault.aspx?tabid=60
www.canola.okstate.edu/index.htm
www.pss.okstate.edu/varietytrials/canola/index.htm
www.soiltesting.okstate.edu/
www.agronomy.ksu.edu/SoilTesting
greatplainscanola.com/
www.plainsoilseedproducts.com/
www.uscanola.com/
www.canola-council.org/
www.agry.purdue.edu/ext/canola/index.htm
www.northerncanola.com/
www.ag.uidaho.edu/brassica/
www.extsoilcrop.colostate.edu/CropVar/canola.html
varietytest.unl.edu/oilseed.html

Publications related to winter canola production may be found at:

www.oznet.ksu.edu/library/
www2.dasnr.okstate.edu/extension/crops

Budgets related to winter canola production may be found at:

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

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2734 (Revised) March 2009

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