Great Plains Canola Production Handbook

Oklahoma State University • Kansas State University • University of Nebraska

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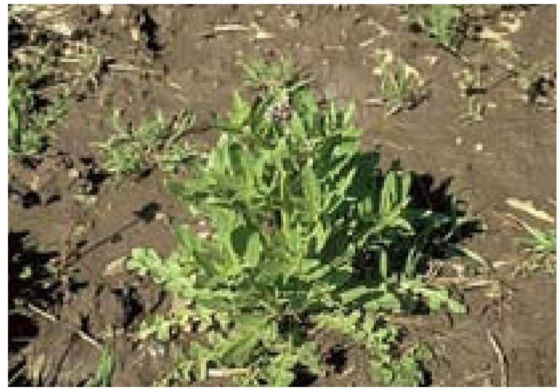

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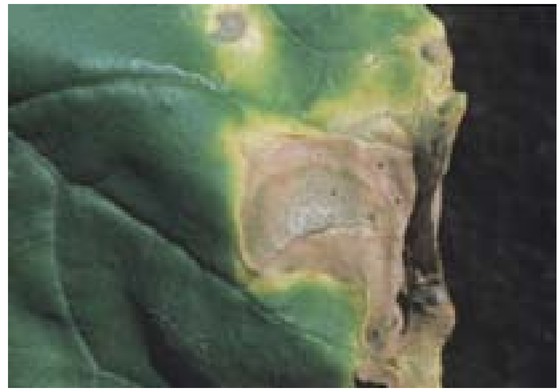

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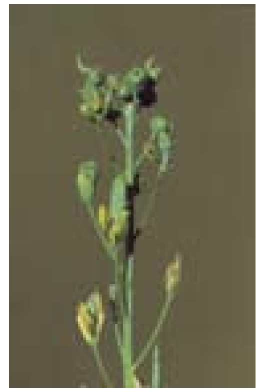
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Summary

Canola is a special type of edible rapeseed genetically low in erucic acid and glucosinolates. The seeds are sources 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.

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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.

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

The first oilseed rape with low levels of erucic acid in the oil was developed in Canada in 1957. Interest in rapeseed increased, and Canadian production reached 1 million acres in 1965. In 1971, 'Span', the first low erucic acid variety, was released. Three years later, '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. 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. Canola oil contains 6 percent saturated fat, the lowest level of any commercially available vegetable oil. In 2006, the FDA authorized products containing canola oil to bear a qualified health claim stating the ability of canola oil to reduce the risk of coronary heart disease due to its unsaturated fat content.

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 large acreage where it is adapted. *Brassica juncea*, yellow 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. Presently, the United States imports the equivalent of 3 million acres of production each year, so a domestic market for the oil and meal exists. Canola breeding and commercial production in the United States were first initiated to satisfy the demand for canola oil as a healthy cooking oil. Additionally, canola oil is a potential feedstock for bio-diesel and production acres are increasing rapidly to meet the growing demand. After canola seed is crushed, the remaining meal is used as a protein supplement for livestock. Small-grain equipment can be used to plant and harvest canola. Yields of winter wheat following canola have shown an 8 to 15 percent increase compared to wheat following wheat, so a positive rotational effect is present.

Both spring and winter types of canola are developed and are grown in the United States. Under ideal conditions, winter types have a 20 to 30 percent greater yield potential than spring types. In the Great Plains, spring types flower approximately 1 month later than winter types, but are harvested only 2 weeks later because of summer heat. This reduced seed-filling period greatly lowers the yield potential of spring types in the Great Plains. Spring varieties also suffer increased pressure from spring weeds and insect pests. Because of these factors, production of spring types is only recommended for rotations requiring spring planting in most of the Great Plains. Winter survival has been a concern with the winter types in the region. However, through cooperative research efforts and private breeders, cold-tolerant varieties have been developed that produce competitive yields in the southern and central Great Plains. Canola is more management intensive than winter and spring cereals; therefore, weekly field scouting is critical to identify production problems 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 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; avoid 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 several of these crops and the recommended time intervals between their production and canola seeding. 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). Do not plant a variety unless it consistently survives winter conditions

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.

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

Herbicide	Crop	Restrictions [a]
Accent	Corn	18 months
Ally	Wheat	18 months
Ally Extra	Wheat	18 months
Amber	Wheat	Field bioassay required
Atrazine	Corn/Sorghum	2nd fall following application
Beyond	Wheat	18 months
Equip	Corn	18 months
Exceed	Corn	10-18 months based on region
Finesse	Wheat	Field bioassay required
Glean	Wheat	18 months
Hornet	Corn	Not specified
Maverick	Wheat	22 months
Olympus	Wheat	22 months
Peak	Wheat/Sorghum	34 months
Permit	Corn/Sorghum/Cotton	Not specified
Priority	Corn	Not specified
Rave	Wheat	Field bioassay required
Spirit	Corn/Sorghum	pH<7.8, 10 months
Staple	Cotton	Field bioassay required

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

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 southern Great Plains, it may not tolerate the rapid fluctuations in temperatures characteristic of the area. The varieties developed in the southern Great Plains have demonstrated excellent winter survival in the region. Other factors that need to be considered when selecting a variety include seed yield, seed oil content, pod shattering resistance, maturity, lodging tolerance, and disease resistance. Varieties possessing Roundup Ready® herbicide resistance, insecticide seed treatments for fall aphids, and sulfonylurea herbicide carryover tolerance are also available.

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

With heightened interest in winter canola production in the region, the number of adapted varieties will increase. A strong regional and national performance testing system was established in 1982. This system allows for the dissemination of data necessary to ensure the best-adapted varieties are commercially available. Grown at more than 50 locations throughout the United States, the National Winter Canola Variety Trial assists farmers in variety selection. A new variety must only be considered after it demonstrates its adaptability over multiple locations and multiple 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 the germplasm pool include the Clearfield® herbicide resistance system, early maturity, early flowering, heat tolerance at flowering, reduced height, and pod shattering resistance. Improved varieties should be available on a regular basis for both spring and winter production. Check with local extension offices or your local seed dealer for adapted varieties and seed availability in your area.

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 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 (seed leaves) 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. The roots also continue to develop. Unlike wheat, whose growing point is protected beneath the soil during early development, the growing point of canola is above the soil between the two cotyledons. Thus, canola seedlings are more susceptible than cereals to environmental hazards.

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.

Rapid establishment of a leaf canopy is important in the development of a canola crop. The larger and more abundant the leaves are, 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 the plant to form its crown above the ground, thereby increasing the chance of winter damage. Additional stress factors during the winter lead to reduced survival. Spring types form considerably smaller rosettes than winter types.

Response to Cold Temperatures and Spring Regrowth of Winter Types

During the winter, growth slows and many apparent physical changes take place. These are a result of decreasing temperature and shorter day length. Leaves often discolor, turn purple, and die. 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. Growth resumes in late winter or early spring as temperatures increase and day length becomes longer. New leaves appear from the growing point.

Budding and Bolting

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 or lengthens. Leaves attached to the main stem unfold, and the cluster of flower buds enlarges as the main stem elongates. Secondary branches develop from buds in the axils of some leaves. Spring types have a lower vernalization requirement and essentially begin bolting and budding as the canopy becomes adequate.

The main stem reaches 30 to 60 percent of its maximum length prior to 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 necessary to provide 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. Secondary branches begin flowering a few days later. Under favorable growing conditions, flowering of the main stem continues for 2 to 4 weeks, 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 growing conditions, such as a late spring frost, cause abortion of flowers or pods, the plant can recover 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 considerably more developed. At this stage, the stem and pod walls are the major sources of nutrients for seed growth. Keep leaves, stems, and pod surfaces free from disease or insect damage. Stresses to the nutrient-production capacity of these plant surfaces lead to a reduction in seed yield.

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 at this time. 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. 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 stem is still green. Mature pods are split easily along the center membrane, and the seed is lost by shattering. Average seed moisture of 10 percent with no green seed visible is ideal for harvest.

Seeding

Small-grain equipment is used to plant canola, but soil conditions are more critical for establishment than for small grains. Factors such as lack of surface soil moisture, soil compaction, crusting, crop residue, and water logging prevent canola establishment. Mitigation 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 (granules up to 1 millimeter in size) and the remainder ranging up to 5 millimeters, with 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. Too coarse seedbeds can result in poor seed placement, seed-to-soil contact, and moisture loss. A moderate amount of crop residue on the soil surface to reduce soil erosion is desirable.

To conserve moisture, make each tillage operation shallower than the one prior. Apply pre-plant fertilizer and herbicide before the final tillage operation of the seedbed. Complete the last tillage operation 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 is a seedbed that has received rain since the last tillage operation. Weeds are controlled by a pre-plant herbicide application rather than by tillage.

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. Varieties with herbicide resistance permit no-till seeding as a viable option for growers. 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 wheat 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.

Seeding Date

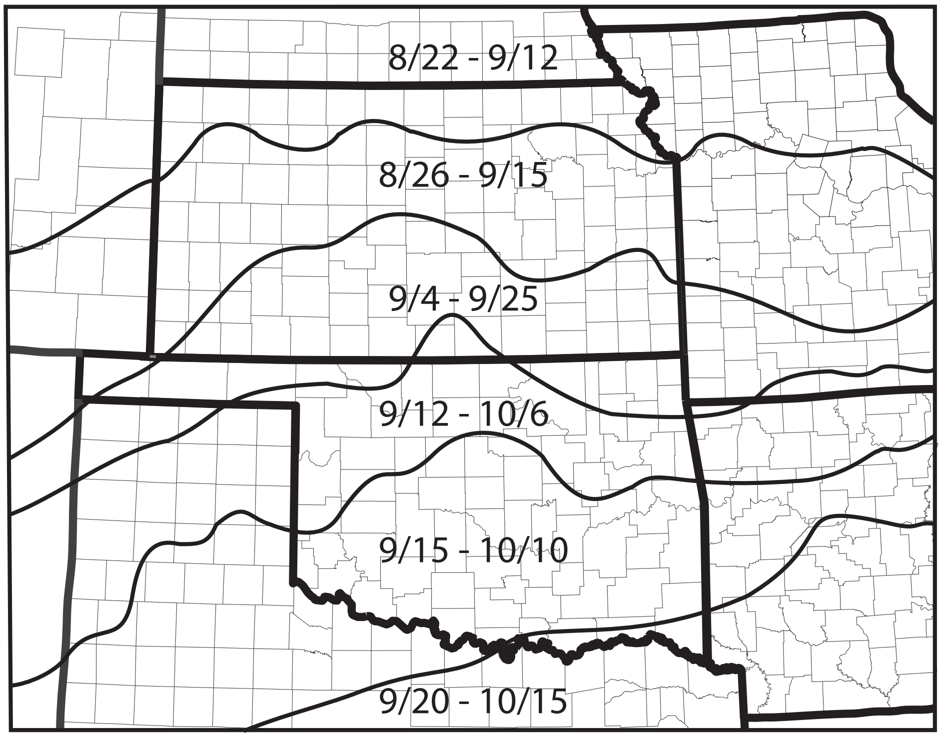
Seeding date is critical to establishing a crop possessing sufficient growth for good winter survival. Generally, plant winter canola 6 weeks before the first killing frost (lower than 25 degrees Fahrenheit) for an area. These planting dates are illustrated in Figure 1. Plant spring types at similar times to oat planting in the High Plains (March into April). Presently seeding dates also may be defined by the availability of crop insurance in your area. Contact local extension or crop insurance agents. 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 early or late planting. Planting date also affects maturity, canopy cover, and weed control.

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 10 plants per square foot is ideal. Usually significant yield differences do not occur unless populations at harvest are less than four or greater than 15 plants per square foot.

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



Carefully evaluate a poorly established crop in the 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 branches. Yield from a stand of this spacing is 60 or 70 percent of the yield from a stand with optimum spacing of six to 10 plants per square foot. Low seeding rates produce thin stands, which can result in uneven maturity. Thin stands also can cause 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 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. With average size seed, 1 pound per acre equals approximately 2.6 seeds per square foot in 7½-inch rows. The percent emergence varies with seed quality, soil conditions, and seeding method. Check the seed tag for seed count per pound to 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 prior to 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. Check drill calibration to ensure desired seeding rates. Seeding rates lower than other crops may make a speed reduction kit necessary, especially on older drills.

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. With planting difficulties of 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 prior to 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 can also 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 prior to 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 3. 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.

Table 3. *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.*

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 4, and general potassium recommendations are given in Table 5. 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.

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. *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

Table 5. *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

Sulfur

Canola has a high demand for sulfur because of its high content of sulfur-containing proteins. While many of the soils in the southern plains contain large amounts of sulfur, some, particularly those with coarse texture and low organic matter contents, can be deficient. A profile soil test can help to identify sulfur responsive fields. Deficiency symptoms are not visible until the plant is severely lacking in sulfur. Young leaves become chlorotic, poorly developed, and cupped. A reddish-purple tinge develops on leaves, and flowers become pale yellow.

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/acre) = 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 6 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 prior to planting in the fall, as samples taken in the spring will reflect both the residual soil nitrogen from the previous crop and mineralized soil nitrogen from organic matter and crop residue.

Applying too much of the recommended nitrogen prior to 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 spring.

Table 6. *Total nitrogen fertilizer needs for canola as affected by yield potential and soil test nitrogen levels on the southern Great Plains.*

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

In 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.

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 prior to 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 N 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

Table 7. *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

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 7.

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 8 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 9). 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 simpler guideline is to apply 20 pounds sulfur per acre, which will be sufficient for low, and medium yield levels. Sulfur can be applied in the fall and incorporated into the seedbed or surface applied with nitrogen in the spring. Sulfur also can be applied in liquid form over the crop.

Weed Management

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. The benefits of weed control 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.

When winter canola is grown in rotation with wheat, it is advisable to avoid growing wheat varieties with high temperature germination sensitivity. Such varieties lead to much worse problems with volunteer wheat as a weed.

Winter canola has difficulty competing with established weeds at emergence. Planting winter canola into a weed-free

Table 8. *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 9. *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

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 preceding herbicide applications.

Planting canola following the application of most sulfonylurea and imidazolinone herbicides should be avoided. These products include, but are not limited to the wheat herbicides Ally, Ally Extra, Amber, Beyond, Finesse Grass and Broadleaf, Glean, Maverick, Olympus, Olympus Flex, Peak, or Rave; corn or sorghum herbicides Accent, Atrazine, Equip, Exceed, Hornet, Peak, Permit, Priority, or Spirit; or the cotton herbicide Staple (Table 2). Canola plant-back restrictions may not always be listed on an 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 ½ 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 10 – 12). They are not labeled for controlling mustards and 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 13 – 18). 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 19 – 26). Apply 1 to 1½ 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.

Before spraying canola, always be sure that filters, spray tip screens, and herbicide-handling equipment are free of herbicide residues that may injure canola. Growth-regulator herbicides and sulfonylurea herbicides can cause significant injury when applied postemergence to canola. Also remember that wheat is very sensitive 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 sensitive to drift from herbicides applied to wheat or to pastures and rangeland.

Diseases

Canola is a member of the mustard family (*Brassicaceae*, formerly *Cruciferae*), which includes such common weeds as mustards, pepperweed (*Lepidium virginicum*), and shepherdspurse (Photo 26). Diseases that affect these weeds may also affect canola. Diseases attack canola at all stages of development. They are commonly soilborne, seedborne, or airborne and spread from infected crop residues. The incidence of major diseases is low, but will likely increase as canola acres increase in the Great Plains.

Blackleg

The blackleg fungus (*Leptosphaeria maculans*) is common worldwide and infects canola and related crops. Blackleg is the most serious threat to canola. There are both mildly aggressive and aggressive strains of the fungus. In 1975, the aggressive form was first reported in Saskatchewan and then 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, infected canola stubble, and 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, known as pycnidiospores, 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.

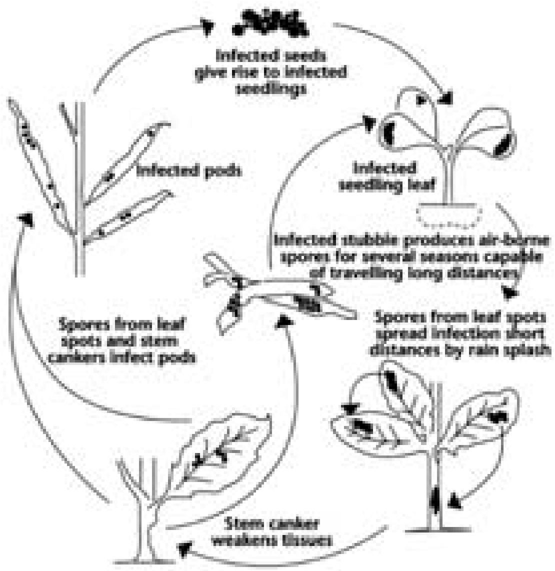
Infections from the mild strain usually occur much later in the season than those from the aggressive strain. Shallow, white to gray lesions will form on the stem, but stems are usually not girdled. Only a few pycnidia (Photos 27 – 29) are formed.

In contrast, the aggressive strain can infect early and produce leaf spots as well as stem lesions. Leaf spots 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 29). 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 treated with a fungicide that is effective against blackleg. Several seed treatment products are registered for control of blackleg including Helix (Thiamethoxam), Maxim (Fludioxonil), Thiram (Thiram), 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 fields in the area. 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.

Figure 2. *Blackleg cycle.*



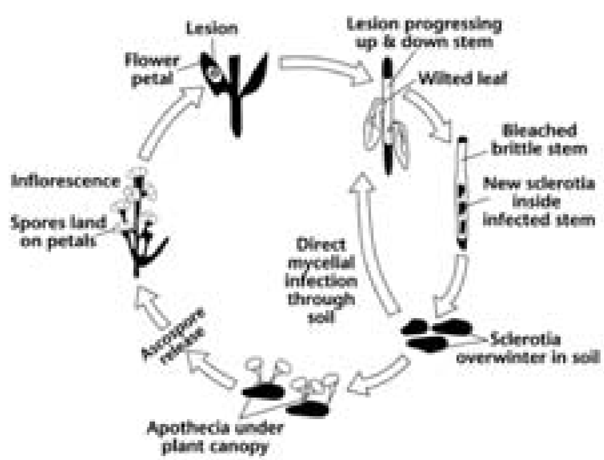
Sclerotinia Stem Rot

Sclerotinia stem rot is caused by the fungus *Sclerotinia sclerotiorum*. It is a serious problem in many areas throughout the world. Sclerotinia (white mold) is most severe under warm, wet conditions when canola is flowering. A wide range of field crop hosts exists including dry beans, sunflowers, and soybeans. 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 when irrigating, keep the soil surface dry during flowering to minimize the risk of this disease.

The first noticeable symptom of Sclerotinia stem rot is the presence of prematurely ripened plants (Photo 30). Stems become bleached and tend to shred (Photo 31). Under high moisture conditions, a white moldy growth may develop on the surface of stems and pods. Hard black structures (Photo 32) 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. 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 become sites for the fungus to invade the plants. 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. However, once the disease is present in the soil, use a 4-year rotation with a nonsusceptible crop. Keep in mind that deeply buried sclerotia remain dormant in the soil for 8 years and can be brought near the surface by cultivation.

Figure 3. *Sclerotinia stem rot cycle.*



To reduce the incidence of conditions favorable for Sclerotinia infection, use lower plant densities and reduce nitrogen rates 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. Quadris and Ronilan (Vinclozolin) are registered for use in managing sclerotinia stem rot. Sclerotinia stem rot is usually more serious in crops like dry beans than canola, yet it is particularly important to include significant time between susceptible crops when canola is in rotations.

Alternaria Black Spot

Damage from Alternaria black spot (caused by the fungi *Alternaria spp.*) 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 (Photo 33 – 34). Often the spots are surrounded by a light green or yellow halo.

Alternaria survives in infested crop residue, on infested seed, and on some alternative weed hosts. Infested seed either rots in the soil or produces infected seedlings. Windblown spores germinate, penetrate plant 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.

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 35). 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

Powdery mildew fungus *(Erysiphe cruciferarum)* is characterized by 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 the fungi including *Pythium spp., Fusarium spp.,* and *Rhizoctonia spp.* This occurs when seeds are planted under adverse conditions, especially excessively cool and wet soils, and results in thin, patchy stands. Losses are rarely serious. Control starts with the use of certified seed planted shallowly into a firm, moist, and 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 plant pathogenic bacteria-like micro-organism). This organism has a very wide host range and infects about 300 species of plants. Plants infected with aster yellows fail to set pods, producing blue-green, sterile, and hollow bladders in place of normal pods (Photo 36). Infected plants remain in a vegetative state during the entire growing season and remain green and taller than normal at harvest. Aster yellows is spread from plant to plant by the aster leafhopper (*Macrosteles quadrilinetus*) (Photo 61) in the fall. No disease management strategies are available, but generally less 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. Because canola is not produced extensively across the Great Plains, information on insect pest thresholds is somewhat limited.

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 37 - 60).

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 Extra) are available.

Insects causing serious problems in the southern Great Plains over the past 10 years include flea beetles, grasshoppers, army cutworms, aphids, and root maggots. Generally, flea beetles are less of a problem with later plantings of winter canola. Flea beetles attack the cotyledons at emergence and the first true leaves of seedlings producing pits or shot holes in leaves. 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, but total stand loss there is likely. Canola is especially palatable to army cutworms. Treatment is necessary in years when army cutworm populations are high. Populations of 4 to 5 per square foot cause severe damage to stands.

Aphids have become the most important insect pests of canola in the southern Great Plains. The turnip aphid has frequently been observed to colonize fields during fall growth, survive mild winters, and increase to damaging levels during the early spring. Cabbage aphids tend to 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 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. Research conducted in Georgia indicates that insecticide treatments are justified during seedling and rosette stages of growth if 20 percent of the plants are infested with aphids. Insecticide treatments may be justified during bud and early bloom stages if 15 percent of the plants are infested, with an average of five cabbage aphids per stem (raceme).

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 prior to 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, alfalfa loopers *(Autographa californica)* (Photo 62), and diamondback moth larvae 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, 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 5 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.

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.

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

Grazing

For centuries, rapeseed was used as high-quality, annual forage in Europe. Investigations are underway to determine canola's potential as a dual-purpose forage/seed crop for use in the Great Plains in much the same manner wheat is used as winter pasture. Early results show that grazing canola can severely 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 than wheat in protein, lower in fiber, and higher in energy (Table 10). 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.

Table 10. *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

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.

It is currently recommended that canola grazing be viewed as opportunistic. Canola's availability and duration as a 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 is either swathed and then harvested or combined directly. The decision to swath or direct cut is a management decision. Both can be done successfully. Swathing is generally recommended for winter canola if harvest cannot be completed in a timely manner. Swathing too early reduces oil content, raises seed moisture content excessively, and increases green seed levels. Swathing too late increases seed loss from shattering. Direct combining can cause excessive seed loss from shattering unless the machine is properly adjusted. When harvesting canola, plug holes in the combine or trucks with tape or caulk to ensure that the seed is not lost.

Harvesting canola is a slower process than harvesting wheat and requires patience. Harvest ripe canola immediately as preharvest shattering happens frequently. 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.

Direct Combining

Direct combining is generally recommended for the southern Great Plains because dry-down is accelerated by sufficiently high air temperatures at harvest. However, canola

Table 11. *Tips for reducing harvest seed loss.*

Step	Procedure
1	Set your combine according to operator's manual
2	Slow down cylinder speed
3	Adjust the concaves
4	Close the sieves
5	Reduce the air
6	Raise the reel
7	Place reel directly above the sickle
8	Match reel speed to ground speed
9	Harvest just below the pods
10	Slow ground speed at first, then adjust if needed
11	Check for leakage on your trucks and combines
12	Aim for 2 percent dockage or less
13	Tarp all trucks for transport

is an indeterminate crop and retains a few immature seeds at harvest. Ideally, canola should be harvested when the average seed moisture is 8 to 10 percent and no green pods are visible.

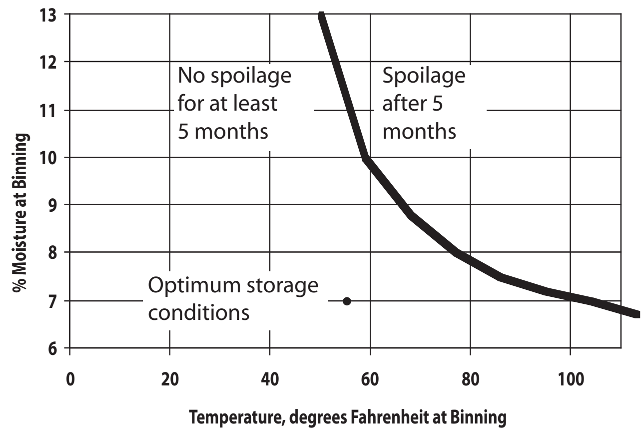
Adjust initial combine settings in accordance with the operator's manual instructions for canola (rapeseed). Harvest canola immediately below the seedpods to avoid excess trash and green stems moving through the combine and slowing harvest (Photo 63). Place the reel as high and as far back over the table as possible. Match the reel speed to the ground speed. Slow the cylinder speed to approximately a half to two-thirds of the setting for most cereals (450 to 650 revolutions per minute (rpm)). Cracked seed indicates excessive cylinder speed. Recommended concave clearances are ¾ inch in the front and ⅛ to ¼ inch in the rear. Fan speed is similar to wheat (400 to 600 rpm). Do not set fan speed too high because shaking the seed out of the chaff is better than blowing it out. Set the top sieve or chaffer at ¼ to ⅜ inch for proper separation, and set the lower cleaning sieve at ⅛ to ¼ inch.

Ripe standing winter canola is very easy to thrash. Therefore, after you first set your combine by the book, try opening the concaves more, which will reduce grinding of stalks. This will let you put 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 unthreshed 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. Table 11 contains tips on how to reduce seed loss at harvest.

Swathing

Uneven field maturity can make swathing a desirable option because of time management concerns with direct harvesting the canola. If swathing is necessary, it is critical that the plants are at the proper stage of maturity. Swath canola when 60 to 75 percent of the seeds are black and contain 30 to 40 percent moisture. Place the swath on stubble for approximately 7 to 10 days, or until the seed moisture is 8 to 10 percent. Swathing is advantageous if environmental conditions promoting shattering exist (hail, hard rain, etc.). However, research in this region shows a yield reduction of approximately 10 percent when canola is swathed at the optimum stage compared to direct combining. This yield reduction is greater when canola is swathed too early or too late. High winds can cause yield loss by blowing swathed windrows out of position.

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



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 and weed infestations are heavy.

Storage

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

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

Optimum Storage Conditions

Canola seed may be conditioned using aeration to reduce moisture and temperature to safe levels for long-term storage. Figure 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

Table 12. *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

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 2½ 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 12 shows the ERH for canola with 40 percent seed oil content at various temperatures and seed moistures. The shaded area shows the optimum seed conditions to prevent mold growth and seed handling damage. For example, a seed temperature of 80 degrees Fahrenheit must have a moisture content of 7.6 percent or less to have an 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 12. 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 ½ 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.

Table 13. *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.

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 13 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. Holes in truck beds, grain carts, and combines must be plugged 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 14 includes example enterprise budgets for wheat for grain-only, conventional canola, and Roundup Ready® canola. Prices of $3.20 per bushel for wheat and $0.085 per pound for canola were used for these example budgets. To more nearly represent a specific situation, an individual producer may adjust the input and production quantities and prices as reported in the table. 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.

Data are not available to determine relative yields for wheat and canola across Oklahoma and Kansas regions and soil types. The example budgets include yields of 40 bushels per acre for wheat and 2,040 pounds per acre for canola.

Nitrogen, harvest costs, and hauling costs 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 soil nitrogen of 15 pounds per acre carryover. For 45 bushels per acre expected yield, the required level of nitrogen, in addition to the expected carryover and that applied in 50 pounds per acre of diammonium phosphate (18-46-0), is estimated to be 56 pounds per acre [(40 bushels per acre × 2 pounds per bushel) – (50 pounds per acre × 0.18) – (15 pounds per acre carryover)]. This requirement can be met with 122 pounds per acre of urea (46-0-0). Similarly, for an expected yield of 2,040 pounds per acre of canola and an expected requirement of 0.05 pounds of nitrogen per pound of canola, 50 pounds per acre of 18-46-0, 21 pounds per acre of 21-0-0-24S, and 15 pounds per acre carryover, 160 pounds of urea would be required per acre. For winter canola, it is recommended that only a third of the nitrogen be applied preplant with the remaining two-thirds applied as a top-dress in February.

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

For the budgets reported in the table, machinery fixed costs, and costs for labor, land, management, overhead, and risk are not included. It is assumed that these excluded costs would 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 as reported in the table.

Enterprise budget software is available to develop budgets customized for a specific field or farm. Oklahoma budgets are also available at *www.agecon.okstate.edu/budgets*. Budgets for regions in Kansas are available online at *www.agmanager.info/crops/budgets/proj_budget*. Oklahoma farmers who are interested in more comprehensive economic analysis for their specific farm 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 14. *Wheat, Conventional Canola, and Roundup Ready Canola per acre production returns and cost estimates.*

Item	Unit of Measure	Price per unit	Wheat (grain-only) Quantity	Wheat (grain-only) Value	Canola (conventional) Quantity	Canola (conventional) Value	Canola (Roundup Ready) Quantity	Canola (Roundup Ready) Value
Production								
Wheat	bu	$3.20	40	$ 128.00				
Canola	lbs	$0.085			2,040	$ 173.40	2,040	$ 173.40
Gross Returns				128.00		173.40		173.40
"Cash" Costs								
Wheat Seed	bu	$9.00	1	9.00				
Canola Seed (conventional)	lb	$1.50			5	7.50		
Canola Seed (Roundup Ready) + Tech. Fee	lb	$3.80					5	19.00
Urea (46-0-0)	lb	$0.16	122	19.48	160	25.60	160	25.60
Diammonium Phosphate (18-46-0)	lb	$0.14	50	7.00	50	7.00	50	7.00
Ammonium Sulfate (21-0-0-24S)	lb	$0.12			21	2.52	21	2.52
Fertilizer Application	acre	$3.25	1	3.25	2.5	8.13	2.5	8.13
Herbicide	acre	$5.00	1	5.00				
Herbicide (e.g. Treflan® (trifluralin))	pint	$2.75			2	5.50		
Herbicide (e.g. Assure II® (quizalofop-p-ethyl))	oz	$1.13			8	9.04		
Herbicide Additive (Crop Oil Conc.)	ac	$1.00			1	1.00		
Herbicide (e.g. Roundup® (glyphosate)	oz	$0.22					32	7.04
Herbicide Additive (ams)	units	$0.125					2	0.25
Herbicide Application	acre	$3.50	1	3.50	2	7.00	2	7.00
Fungicide (e.g. Apron (metalaxyl) seed treatment)	lb seed	$0.10			5	0.50		
Insecticide (seed treatment)	acre	$6.00			1	6.00	1	6.00
Insecticide (e.g. dimethoate)	pint	$4.00	0.75	3.00				
Insecticide (e.g. Warrior® (lambda-cyhalothrin))	oz	$2.07			3	6.21	3	6.21
Aerial Pesticide Application	acre	$4.00	1	4.00	1	4.00	1	4.00
Wheat Crop Insurance (minimal coverage)	acre	$3.00	1	3.00				
Canola Crop Insurance (minimal coverage)	acre	$3.15			1	3.15	1	3.15
Fuel Lube and Repair	acre			10.00		12.50		10.00
Annual Operating Capital	$	$0.07	34	2.35	53	3.70	53	3.71
Wheat Custom Harvest & Haul								
Base Charge	acre	$15.00	1	15.00				
Excess for >= 20 bu/a	bu	$0.15	20	3.00				
Hauling	bu	$0.15	40	6.00				
Canola Custom Harvest & Haul								
Base Charge	acre	$18.00			1	18.00	1	18.00
Excess for > 12.5 cwt/a	cwt	$0.32			7.9	2.53	7.9	2.53
Hauling	cwt	$0.32			20.40	6.53	20.40	6.53
Total "Cash" Costs	$/acre			$ 94		$ 136		$ 137
Return to Machinery and Equipment Fixed Cost, and Labor, Land, Management, and Overhead	$/acre			$ 34		$ 37		$ 37

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Insect Pest Identification and Control Photos

(see pages 11 – 12 for descriptions)

Photo 37. *Wireworm.*

Photo 38. *Flea beetle.*

Photo 39. *Fall armyworm.*

Photo 40. *Beet armyworm.*

Photo 41. *Army cutworm.*

Photo 42. *Imported cabbage worm adult.*

Photo 43. *Imported cabbage worm larva.*

Photo 44. *Southern cabbage worm.*

Insect Pest Identification and Control Photos *(Continued)*

(see pages 11 – 12 for descriptions)

Photo 45. *Cabbage looper.*

Photo 46. *Diamondback moth larva.*

Photo 47. *Diamondback moth adult.*

Photo 48. *Cabbage aphid.*

Photo 49. *Green peach aphid.*

Photo 50. *Turnip aphid.*

Photo 51. *Aphids on canola.*

Photo 52. *Harlequin bug.*

Insect Pest Identification and Control Photos *(Continued)*

(see pages 11 – 12 for descriptions)

Photo 53. *False chinch bug.*

Photo 54. *False chinch bug on bud.*

Photo 55. *Cabbage seedpod weevil adult.*

Photo 56. *Cabbage seedpod weevil larva.*

Photo 57. *Red turnip beetle.*

Photo 58. *Thrips.*

Insect Pest Identification and Control Photos *(Continued)*

(see pages 11 – 12 for descriptions)

Photo 59. *Cabbage root maggot.*

Photo 60. *Lygus bug.*

Photo 61. *Aster leafhopper.*

Photo 62. *Alfalfa looper.*

Harvest

(see page 13 for descriptions)

Photo 63. *Canola harvest.*

Nutrient Deficiencies


Photo 64. *Nitrogen deficiency.*


Photo 65. *Nitrogen deficient leaves, sufficient leaf on right.*


Photo 66. *Nitrogen deficient plant on left, sufficient on right.*


Photo 67. *Potassium deficiency.*


Photo 68. *Potassium deficient leaves.*


Photo 69. *Phosphorus deficiency.*


Photo 70. *Phosphorus deficient leaf.*


Photo 71. *Sulfur deficient plant.*

Nutrient Deficiencies *(Continued)*

Photo 72. *Sulfur deficient leaves, sufficient leaf on right.*

Photo 73. *Sulfur, potassium, phosphorus, and nitrogen deficient pods, sufficient pod on the right.*

Photo 74. *Top left — sufficient; top right — nitrogen deficient; lower left — phosphorous deficient; lower right — potassium deficient.*

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