# 6. Spring and Winter Canola

Canola is a cool-season oilseed crop well suited to the temperate areas of Ontario. Seeding and management of winter canola are similar to that of spring canola. The differences in required management are outlined below.

Canola is a member of the botanical family *Brassiccae,* which includes wild radish (grown as a cover crop), rutabaga, mustard, cauliflower, cabbage and broccoli. Canola varieties must contain less than 30 µmol/g glucosinolates and less than 2% erucic acid. Average oil content is 40%–45%. Varieties grown in Ontario belong to *Brassicae napus* (Argentine), which is distinguished from other species by the shape of its upper leaves. Canola leaves are waxy, dark bluish green with shallow lobed leaves while mustard has light green, hairy and deeply lobed leaves.

## Tillage Options

### Conventional Tillage

Conventional tillage (i.e., mouldboard, chisel) is being replaced by lower disturbance, high residue tillage systems on many farms. Fall primary tillage is preferred by some producers on clay or clay loam soils so that spring tillage establishes a suitable seedbed. However, keep spring secondary tillage to a minimum to preserve soil moisture, minimize the risk of crusting, and reduce the risk of heavy spring rains causing serious soil erosion. A granular, well-aggregated seedbed that provides good seed-to-soil contact is preferred to a fine seedbed.

### Reduced Tillage and No-Till

Seeding canola with reduced tillage and no-till systems has proven very successful provided the seeding equipment can place the seed below the residue and in firm contact with the soil. The foundation of successfully adopting no-till seeding begins with residue management at harvest in the year prior to seeding canola. If crop residue (straw and chaff) is not spread uniformly, seeding equipment may not achieve good seed placement and seedlings will have difficulty emerging through a mat of residue. Uneven residue distribution creates an ideal habitat for slugs. No-till canola into cereal residue is not recommended due to risk of stand loss from slugs. Some tillage tools will disturb residue, disrupt habitat for slugs, and distribute straw and chaff evenly to aid in seed placement. Seed-firming wheels of the no-till drill should press seed into the bottom of the shallow seed trench to ensure adequate seed-to-soil contact. No-till seeding into most residue types works, including corn stalks if the appropriate and properly adjusted equipment is used.

### Site Selection and Crop Rotation

Canola responds best to well-drained soils with a minimum pH of 5.5. Fields with variable drainage and pH will have variable stands and yield. On soils with low moisture holding capacity, spring cereals are more resilient to dry growing conditions than spring canola.

Winter canola requires better drainage than winter wheat and therefore should be grown on well-drained soils. Winter canola generally has good tolerance to freezing temperatures but reasons for poor winter survival include root heaving, root rot and freeze injury from ice accumulation often occurring where canola is planted into heavy or poorly drained soils.

Crop rotation is an excellent way to reduce build-up of diseases and insects. Rotations of 3–4 years between canola are recommended. Long rotations with non-host crops for *Sclerotinia* (white mould), blackleg and swede midge will help reduce buildup of these pests in canola. To mitigate buildup of swede midge populations it is also necessary to control cruciferous weeds throughout the rotation, including mustard, shepherd's-purse, field pepperweed, stinkweed, yellow rocket and radish. However, any canola fields nearby may contribute to a local swede midge population.

Rotation is also important in managing herbicide carryover, since canola is particularly sensitive to several Group 2 products. Herbicide carryover is higher on soils with low organic matter, soils with high or low pH, and under very dry conditions because of the reduced level of herbicide breakdown. For specific product precautions for herbicide carryover, refer to OMAFRA Publication 75, Table 4–4, *Herbicide Crop Rotations* and *pH Restrictions-Field Crops.*

Do not locate winter canola within 5 km of where rutabagas are grown. Both crops are hosts for turnip mosaic virus. Serious crop losses have occurred in rutabagas from this disease.

Corn should not follow canola in the rotation because of the potential for phosphorous deficiency. Corn roots establish a strong relationship with beneficial soil fungi called vesicular arbuscular mycorrhizae (VAM) fungi, which aids in phosphorus uptake. VAM colonization on roots of corn seedlings is diminished when corn follows canola, resulting in increased incidence of phosphorus deficiency.

Canola is versatile in a crop rotation. Canola harvest dates allow for timely winter wheat planting. Many producers report their best winter wheat yields following canola in the rotation. Following canola harvest there will likely be a high number of volunteer canola plants. While most will die over the winter, control any volunteer canola present in the spring early-on, before they grow large and become difficult to manage.

## Variety Selection

Yield and variety traits for the cultivars tested by the Ontario Soybean and Canola Committee can be found on the www.gosoy.ca. It is important to select superior varieties that have demonstrated stable yield performance in multi-site and multi-year data reports.

Aside from yield, other canola traits to consider include:

- lodging resistance
- herbicide system (e.g., Liberty Link, Roundup Ready, Pursuit Tolerant)
- disease resistance (e.g., blackleg, *white mould* etc.)
- low percentage of green and brown seeds
- tolerance to pod shatter

All canola varieties presently grown in Ontario are hybrid varieties and belong to the *Brassica napus* species and have good resistance to blackleg, although varieties differ in their level of resistance. If seed is imported, a phytosanitary certificate provides assurance that canola seed is free of blackleg, a serious disease that can be seed or soil-borne. Some companies have also been able to successfully develop varieties with increased tolerance to *Sclerotinia*.

The majority of canola being grown in Ontario is tolerant to glufosinate (Liberty) or glyphosate herbicide and was developed by genetic modification technology (GMO). There are also varieties tolerant to imidazolinones (IMI tolerant), the active ingredient in herbicides such as Pursuit. IMI tolerant varieties were developed through natural selection of mutations from conventional varieties.

Select varieties genetically adapted to low green and brown seed count. The length of the growing season and weather stress during seed fill has the largest impact on green and brown seed, but genetics also plays a role. If the seeds are green or brown inside (pale yellow is normal) when crushed the oil quality and ultimate market value of the canola are affected, so presence of green and brown seed can cause down-grading or rejection of canola.

## Planting

Stand establishment is one of the greatest challenges in canola production and poor establishment can often be traced back to seedbed preparation, dry soil conditions, and/or crusting. Canola seeding should focus on reducing early stress. The yield potential of canola is determined in the first 24 days after planting. Canola has small seed size compared to most other crops. The limited food reserves of small seeds means that the time from germination to emergence must occur rapidly to ensure adequate plant stands. Conditions that slow down canola emergence greatly impact plant stand and ultimately crop yield.

### Seed Quality

Ensure the seed being planted is of high quality. Germination is the major seed quality consideration used in grading seed lots and certified seed must meet purity and germination standards. Germination standards test the ability of a seed lot to produce normal seedlings under favourable conditions of 95%–100% humidity and 25°C. Stress conditions in the field following planting often reduce field emergence compared to lab results. Some seed companies test seed for vigour, which measures the potential for rapid, uniform emergence and seedling development under sub-optimal conditions. Select seed that has received a germination and/or vigour test within 3–4 months prior to seeding. It is recommended to retain seed tags and a sample of seed following planting in case there are potential seed issues. Certified No.1 canola seed has a germination of 90% or greater and certified No. 2 has 80%–90% germination.

### Seed Treatments

Certified seed is treated with fungicide and insecticide. The fungicide controls seed-borne and early-season soil-borne diseases, including blackleg, seed decay, damping-off and seedling blight. Insecticide seed treatments are required to provide control of low to moderate populations of flea beetles that feed on young seedlings. Control may not be adequate if flea beetle populations are high or canola is slow to develop. Scouting to monitor flea beetle control is critical to staying ahead of this pest. Refer to Chapter 15, *Insects and Pests of Field Crops* for additional information on flea beetle. Insecticide seed treatments that control cutworms are recommended in growing regions where cutworm is a common pest.

### Winter Canola Seeding

Seed winter canola so that canola develops 4–6 leaves and an adequate root system (1.25 cm (0.5 in.) diameter) before winter. Adequate fall growth will reduce risk of frost heaving and spring desiccation. Seed winter canola between August 15 and August 30, or in southwestern Ontario between August 20 and September 10. Delays beyond these dates greatly increase the risk of winterkill. If canola is planted too early and bolts in the fall it will not survive through winter. Heavy competition from weeds or volunteer cereals in the fall can force rapid canola growth and increase the chances of winterkill.

Dry weather following planting can be an issue when seeding in August, resulting in delayed emergence. Prepare the seedbed with a minimum of tillage to conserve moisture and pack following planting to ensure good seed to soil contact.

Where winter canola follows cereals, some tillage of the residue prior to seeding is suggested to reduce the risk of slugs, which can be a problem some years. Attention at cereal harvest to reduce large clumps of straw, and improve uniformity of chaff and straw spreading is important in successfully seeding canola. Tillage coulters and disc openers must cut cleanly through residue to ensure good seed placement and seed to soil contact.

### Spring Canola Seeding

Seed as early as soil conditions permit. Canola will germinate and grow at soil temperatures of 2°C, but 10°C is ideal for rapid emergence. Sustained low soil temperatures have a detrimental effect on the seed embryo. Soil conditions and weather forecasts should be the ultimate guide, however 5°C or higher is a reasonable target for planting. At 6°C, emergence reaches 100% within 8 days. When seedlings emerge the growing point is exposed between the cotyledon leaves (seed leaves). Canola seedlings can withstand a considerable frost of -5°C to -8°C if plants have become acclimatized following a few days of cold temperatures. However, canola seedlings growing under warm conditions will be tender, and can be killed by even a few degrees frost. Increasing seeding rates by 5%–10% when canola is planted very early will help to compensate for slower emergence and increased seedling mortality.

Early April seeded canola has higher risk of mortality from seedling disease, soil crusting, and flea beetles. Early planted canola also has a higher risk of infestation by cabbage seedpod weevil during the flowering/early pod stage. Be prepared to control flea beetles if canola is slow to develop beyond the susceptible stage (i.e., up to 4 true leaves). Seed canola by early May to reduce the risk of damage by swede midge. Refer to Chapter 15, *Insects and Pests of Field Crops* for additional information on swede midge. Photo 6–1 shows the stunted and malformed canola plant resulting from swede midge infestation.

**Photo 6–1.** Swede midge in canola at bolting results in stunted and malformed plants.

If seeding is delayed, it is critical to conserve soil moisture and to plant into moisture for rapid, uniform emergence. Shallow planted, small canola seedlings die easily when they run out of soil moisture. Late seeded canola carries significant risk of swede midge damage in areas with this pest.

Broadcast seeding of canola should only be practiced where there is no option of using a seed drill. Broadcasting can be effective when seeded early and where adequate moisture is sustained throughout the germination and emergence period. Some producers broadcast canola seed with fertilizer onto a prepared seedbed. The advantages of broadcast seeding are higher yield potential due to early seeding date, time savings and low cost. The major disadvantage of broadcast seeding is uneven planting depth and seeding uniformity. Higher seeding rates (10%–15% increase) are often required for broadcasting compared to drilling. Frost injury is also a risk with an early seeding date. Good seedbed preparation ahead of broadcasting followed by harrowing or packing helps to keep seed depth constant and ensure good seed-to-soil contact. Broadcast stands can be inconsistent in dry years.

## Seeding Conditions

The seedbed should be level, firm, and crumbly with soil moisture in the top 2.5 cm (1 in.). A firm seedbed will help hold moisture near the surface and aid in uniform planting depth and uniform emergence. A crumbly soil with a minimum of 30% residue cover will resist crusting after pounding rains, allowing the tiny seedlings to emerge. This is critical, since there is no opportunity to correct crusting. The crust can break the hypocotyl arch (the seedling stem) that lifts the cotyledons above the soil surface.

## Seeding Rate

Adjust seeding rates for the expected emergence rate in a given field based on factors such as soil type, weather, planting equipment and planting date. The optimum plant stand is 75–130 healthy plants/m$^2$ (7–13 plants/ft$^2$) while 54 plants/m$^2$ (5 plants/ft$^2$) is the minimum for maintaining yield potential. In a 19 cm (7.5 in.) row width this is equivalent to 14–25 plants/m (4.5–6 plants/ft) of row. The average seeding rate for canola is 5–6.2 kg/ha (4.5–5.5 lb/acre). To determine the seeding rate that will achieve the optimum plant stand, the seed size, germination or vigour rate on the seed tag, and the expected emergence in a given field must be considered.

Canola seed size can vary greatly between varieties. Seed size has not been found to influence rate of emergence or yield. Calculate the target seeding rate in kg/ha (or lb/acre), using the 1,000 seed weight in grams found on the seed tag. Include the percent germination on the seed tag, and the expected emergence in the given field in the seeding rate calculation. See the *Seeding Rate Example,* for seeding rate calculations.

### Seeding Rate Example

The seeding rate can be determined by knowing the 1,000 seed weight in grams, found on the seed tag, and using the following formula:

**Metric**
Seeding rate (kg/ha)
= (desired plant population/m$^2$ x 1,000 seed weight in grams ÷ seedling survival rate) ÷ 100

**Imperial**
Seeding rate (lb/acre)
= (desired plant population/ft$^2$ x 1,000 seed weight in grams ÷ seedling survival rate) ÷ 10.4

Seedling survival (final stand)
= % germination (on seed tag) x % expected emergence

**Sample Calculation**
Using seed size of 5 g/1,000 seeds, 90% germination guarantee on No.1 seed and 75% expected emergence

Seedling survival
=0.9 x 0.75
=0.675

Seeding Rate (kg/ha)
= 75 plants/m$^2$ x 5 g ÷ 0.675 ÷ 100
= 5.6 kg/ha

Seeding Rate (lb/acre)
= 7 plants/ft$^2$ x 5 g ÷ 0.675 ÷ 10.4
= 5.0 lb/acre

Table 6–1, *Canola seeding rate* provides target seeding rates under two different expected emergence rates of 75% and 60%. If conditions are such that only 60% emergence is expected, higher amounts of seed are called for to achieve an adequate plant stand. In Table 6–1, the targeted plant stand is 75 plants/m$^2$ (7 plants/ft$^2$), and seedling survival equals 90% germination multiplied by 75% or 60% expected emergence. Increase seeding rates if a plant stand greater than 75 plants/m$^2$ is desired.

**Table 6–1.** Canola seeding rate

| 1,000 Seed Weight | Target Seeding Rate | | Seed per opener per 30.5 m (100 ft) of travel on 19.5-cm (7.5-in.) rows | |
|---|---|---|---|---|
| | 75% Emergence 22 plants/m of row (6.7 seeds/ft of row) | 60% Emergence 27 plants/m of row (8.2 seeds/ft of row) | 75% Emergence | 60% Emergence |
| 2.5 g | 2.8 kg/ha (2.5 lb/acre) | 3.5 kg/ha (3.2 lb/acre) | 1.7 g | 2.0 g |
| 3 g | 3.3 kg/ha (3.0 lb/acre) | 4.2 kg/ha (3.8 lb/acre) | 2.0 g | 2.5 g |
| 3.5 g | 3.9 kg/ha (3.5 lb/acre) | 4.9 kg/ha (4.4 lb/acre) | 2.3 g | 2.9 g |
| 4 g | 4.4 kg/ha (4.0 lb/acre) | 5.6 kg/ha (5.0 lb/acre) | 2.7 g | 3.3 g |
| 4.5 g | 5.0 kg/ha (4.5 lb/acre) | 6.2 kg/ha (5.6 lb/acre) | 3.0 g | 3.7 g |
| 5 g | 5.6 kg/ha (5.0 lb/acre) | 6.9 kg/ha (6.2 lb/acre) | 3.3 g | 4.1 g |
| 5.5 g | 6.1 kg/ha (5.5 lb/acre) | 7.6 kg/ha (6.8 lb/acre) | 3.7 g | 4.5 g |
| 6 g | 6.7 kg/ha (6.0 lb/acre) | 8.3 kg/ha (7.5 lb/acre) | 4.0 g | 4.9 g |
| 6.5 g | 7.2 kg/ha (6.5 lb/acre) | 9.0 kg/ha (8.1 lb/acre) | 4.4 g | 5.3 g |
| 100 kg/ha = 90 lb/acre | | | | |

Table 6–1 also shows the amount of seed in grams that should be collected from one seed opener for each of the given seeding rates at 75% or 60% expected emergence. More seed will be needed to achieve the appropriate plant stand if the expected emergence is only 60%.

## Checking Conventional Drill Calibration

Once the appropriate seeding rate has been selected check equipment calibration using the following procedure:

1. Measure out 30.5 m (100 ft). An alternate method is to jack up the drive wheel end of the drill and turn the wheel the number of times to equal 30.5 m of seeded length.

2. Collect the seed from individual openers over this distance. Check several openers across the drill to ensure each run is accurate. If unsure where to begin to set seed cup openers, start with the width of 3 dimes. Weigh the collected seed.

3. Refer to Table 6–1, *Canola seeding rate* for correct grams of seed for either 60% or 75% final emergence in 19.5-cm (7.5-in.) rows.

4. For other row widths use the formula:

$$\text{Seeding rate (kg/ha)} = \frac{\text{area (100 m}^2\text{/ha) x weight of seed collected (kg)}}{\text{width of drill runs collected (m) x length of measured strip (m)}}$$

$$\text{Seeding rate (lb/acre)} = \frac{\text{area (43560 ft}^2\text{/acre) x weight of seed collected (lbs)}}{\text{width of drill runs collected (ft) x length of measured strip (ft)}}$$

5. Record seeding rate and drill settings for next year.

Emergence and seedling survival will be influenced by planting date, seeding depth, soil type and seedling diseases. In a survey of canola fields in western Canada, only 40%–60% of planted seed typically produced viable seedlings. Similarly, in Ontario it is expected that under good conditions a 75% emergence rate is reasonable but under average conditions around 60% emergence is a reasonable reference point for seeding rate calculations. Use seeding rates at the high end of the suggested range on soils prone to crusting, when seeding under cool conditions, or when seeding very late.

Increasing the seeding rate may increase emergence and the density of the plant stand, but does not necessarily increase final yield. Canola is considered a "plastic" plant in that is adjusts to its surrounding environment and can compensate for wide variations in population with very little effect on final yield. In a higher density stand, the canola plants will produce fewer branches. Higher density stands may be more uniform in terms of pod formation and maturation, where lower density stands with more branching may have a longer flowering period and take longer to mature. Dense populations may have thinner stalks and increased lodging, but are more competitive with weeds and may be preferred where high flea beetle damage is expected. When moisture is limited, low density stands may not be able produce adequate yields.

### Seed Bulking

Achieving the target canola seeding rates can be a challenge with some older conventional style drills. Calibrate seeding equipment before heading to the field. Ensure that each of the drill's seed cup openings is set the same. Slow-speed sprockets and/or seed bulking agents can be used with conventional drills to fine tune seeding rates. Bulking of seed with pelletized elemental sulphur, monoammonium phosphate (MAP), MicroEssentials Sulphur + Zinc (MESZ), or corn cob grits are options for improving seeding rate accuracy. Do not use other fertilizers with canola seed due to risk of reduced seed germination and emergence from salt toxicity.

### Seeding Depth

Rapid and uniform emergence is the goal for planting. Sowing depth has a major effect on seedling vigour. Seed 1.25–2.5 cm (0.5–1 in.) deep if there is adequate moisture, and deeper if necessary to plant 0.6 cm (0.25 in.) into moisture. Do not plant deeper than 4 cm (1.5 in.). Emergence of seed planted at 4 cm can be decreased by 50%–60% compared to planting at optimum depth. Seeding into moisture will support uniform emergence and growth that will help with timing of weed control, pesticides and harvest. Dry conditions at seeding or in the following week can increase seedling mortality significantly.

Check seed placement relative to the depth of the openers. On some drills, running the disks at 2.5 cm (1 in.) may only result in seed being dropped at the surface. To compensate, set the boot at the lowest setting on the disk, and adjust the depth of the openers. Press wheels on the drill help place the seed uniformly at the bottom of the seed trench. Drill bounce is more of a problem at speeds over 8 km/h. If canola is seeded through the grass seed box, seed tubes should be directed behind openers and in front of the press wheels. Photo 6–2 shows canola emerging from 2.5 cm (1 in.) seeding depth.

**Photo 6–2.** Canola seedling emerging from a 2.5 cm (1 in.) seeding depth.

### Packing

Soil conditions will determine whether to pack the seedbed before or after seeding. Packing before seeding can help level and firm the seedbed, improving seeding depth control and reducing soil moisture loss. Packing after planting can improve emergence and yield, if the soil is prone to drying out before crop emergence. Packing after seeding may bury the seed deeper if the seed row was ridged by seeding equipment and can increase risk of crusting when followed with pounding rains.

### Assessing Canola Stands and Replant Decisions

The optimum plant stand is 75–130 plants/$m^2$ (7–13 plants/$ft^2$). To evaluate the effectiveness of planting, check the field population about 3 weeks after planting. Plant populations can be assessed by using a hula hoop method. See Appendix K, *Hula Hoop Method for Determining Plant and Pest Populations*. Check populations in several areas of the field.

Generally, canola plants in thin stands will branch out aggressively to compensate, resulting in no significant yield loss. A stand of 20–40 healthy plants/m² (2–4 plants/ft²) can produce a viable crop yielding about 90% of an optimum stand. Uniformly thin stands will perform better than uneven stands, and thin stands may mature a bit late. A 90% yield potential is often better than re-seeding, which results in higher costs and late seeding.

To make a decision, assess the health and plant population of the surviving stand. It is easy to overestimate the extent of the injury and underestimate the ability of seedlings to recover. If plant populations are below 40 healthy plants/m² (4 plants/ft²) prior to the 4-leaf stage, consider the percent of field affected, uniformity of the stand, soil moisture, weed pressure, flea beetle pressure, and the costs and calendar date of reseeding. Assess root health remembering that seed fungicide treatments provide control of seedling blights for 2–3 weeks. Signs of poor root health include brown discoloration of taproot and pinching off of the plant stem near the soil surface.

## Crop Development

Canola development is aligned with growing degree days (GDD) and the amount of sunlight captured. Canola grows best at temperatures between 10°C–30°C, with an optimum of 18°C–25°C. The average crop flowers 45–50 days (582–666 GDD) after emergence and matures in 90–96 days. Northern growing areas such as New Liskeard receive less GDD, but this is partially offset by longer daylight hours. The average number of days to maturity is 10–14 days longer in northern areas than western Ontario. The approximate GDD to reach various stages of development are presented in Table 6–2, *Approximate growing degree days to reach various stages of spring canola development*.

Maturity differences among varieties are typically less than 7 days. When canola planting date is delayed, plants adjust by growing more rapidly through the vegetative stages in response to higher temperatures typically present at this time. As a general guide, a 1 week delay in planting will delay maturity by 3 days. High temperatures (i.e., above 28°C) at flowering cause flower and pod abortion and have a significant impact on yield. Drought and heat stress will shorten the days to reach maturity.

### *Root System*

Canola has a large main taproot that can extend up to 1.5 m (4.9 ft) deep into the soil under favourable growing conditions. Despite its taproot, canola is not capable of penetrating a soil hard pan and is susceptible to soil compaction. About 70% of the canola root system is located in top 15 cm (6 in.) of the soil profile. Early season root growth has a strong positive relationship to final yield. During early vegetative growth, moist topsoil and dry subsoil will result in a shallow root system. Canola roots will not grow in search of water or nutrients, they only intercept water or nutrients present in the soil. Soil compaction, weed competition, or dry soil can limit root growth and make potential canola yields more dependent on timely rainfall during flowering and pod fill. Root growth peaks at flowering.

**Table 6–2.** Approximate growing degree days to reach various stages of spring canola development

**Legend:** Decimal indicates number of leaves exposed.

| Growth Stage (decimal code system) | Description | Growing Degree Days (Base 0°C)[1] |
|---|---|---|
| 0–1.0 | emergence | 152–186 |
| 1.0 | cotyledons unfolded | |
| 1.1–1.2 | 1–2-leaf stage | 282–324 |
| 1.4–1.6 | 4–6-leaf stage | 411–463 |
| 2.0–2.2 | bolting — internode lengthening | |
| 3.0–3.9 | bud development | 582–666 |
| 4.0–4.9 | flowering— 20% of all buds on main raceme flowering or flowered | 759–852 |
| 5.1–5.9 | pod development | 855–1,400 |
| 6.0–7.9 | seed development | |
| 8.1–8.4 | ripening and maturity[2] swathing stage | 1,432–1,557 |

[1] Adapted using research data from Agriculture and Agri-Food Canada (AAFC), Scott and Swift Current.
[2] Occurs when seed begins to mature, 10% seed colour change.

### Plant Development

Germination of canola is similar to other dicots. Emergence generally occurs between 4 and 15 days after planting, depending on soil and climatic conditions. The small seed will only sustain growth for approximately 7 days before accessing nutrients from the soil or through photosynthesis. Canola seedling mortality can be high unless quick, uniform emergence occurs. At emergence the root of canola seedlings will be approximately 3–5 cm (1.2–2 in.) long. The first true leaf appears about 4–8 days after emergence. Photo 6–3 shows a canola seedling at the first leaf stage. The seedling has its first true leaves with 2 cotyledons visible. The growing point of canola is located between cotyledon leaves (seed leaves) and is susceptible to frost, flea beetle injury and hail damage. Leaf area development is directly related to growth rate and final yield. Growth up to the 4-leaf stage is often quite slow, making canola a poor competitor with weeds.

**Photo 6–3.** Canola seedling at first leaf stage.

Canola develops up to 6 waxy, hairless leaves in a rosette before beginning the stem elongation stage. Young leaves develop in the centre of the rosette. Achieving and maintaining a high leaf area is associated with higher yield. Winter canola should reach the rosette stage before overwintering. Outer leaves of the rosette may die over winter but plants remain viable if the crown is not injured and the plants do not heave out of the soil.

For spring and winter canola, lengthening days and rising temperatures in the spring trigger bud formation in the centre of the rosette and the stem rapidly "bolts". About 3–5 secondary branches will develop from leaf axils along the main stem. The main stem will reach maximum length around the same time as peak flowering. At lower plant populations, canola will produce a thicker main stalk and branch more profusely. The increased branching results in plants flowering over a longer period and taking longer to fully mature. The stem is an important source of photosynthate during pod and seed fill.

### Flowering

Flowering begins with the opening of the lowest bud on the main stem and continues upward on both main and secondary branches. Individual flowers remain receptive to pollination for 3 days after opening, and flowering continues for 14–21 days. Canola produces more buds than can be developed into pods, and abortion of flowers and pods is normal. Canola can either self-pollinate or cross-pollinate, depending on various environmental factors. Fertilization occurs within 24 hours of pollination. Temperature stress (>28°C) during this period causes flower abortion and is detrimental to yield.

### Ripening

Seed filling is complete 30–40 days after flowering. Pod ripening starts from the bottom of the plant; there may be developing pods at the bottom of the plant while flower buds are forming near the top. When seeds have turned green, leaf senescence begins, and the pod wall becomes the major source of photosynthate, although the stem is also important. Temperature or drought stress during pod development can cause pod abortion.

Seed from mature Argentine varieties *(Brassica napus)* is brown to black in colour, and as seeds mature and coat colour changes the inside of the seed (embryo) also begins to lose its green colour. Seed colour change begins at the bottom of the plant and progresses up the main stem as moisture content decreases. When 30%–40% of seed on the main stem has started to change seed coat colour, overall moisture content will be around 30%–35% and the seeds in the last formed pods are completing filling. Seed colour change advances by about 10% every 2–3 days; the rate increases in hot weather and may decrease in cool weather. The colour of the pod when seeds are mature will vary depending on the variety and environment, so the pod or plant colour visible across the field is not a good indication of seed maturity or moisture content. Fully mature pods will shatter easily and lose seed.

## Fertility Management

### Placement and Timing

Most fertilizer for canola is broadcast. The high rates of nitrogen required, and the seeding methods used, make it inconvenient and risky to band fertilizers. There may be occasions; particularly where phosphorus soil-fertility levels are low, when up to 20 kg/ha (18 lb/acre) of phosphorus application with the seed would be advantageous.

### Nitrogen

#### *Spring Canola*

Canola has a great demand for nitrogen. The nitrogen fertilizer guidelines for canola in Table 6–3, *Nitrogen guidelines for spring canola,* are based on the price ratio between canola and nitrogen fertilizer. Nitrogen should not be placed with the seed. Nitrogen fertilizer is typically broadcast in canola in the spring, but where equipment allows can be banded 5–7.5 cm (2–3 in.) to the side of the seed row.

Adjust rates downward if manure was applied or if the previous crop contained legumes such as alfalfa. See Table 9–9, *Adjustment of nitrogen requirement where crops containing legumes are plowed down* and Table 9–10, *Typical amounts of total and available nitrogen, phosphate and potash from various organic nutrient sources and average concentrations*. Excessive nitrogen on canola has been linked to increased incidence of green seed and can also increase the number of days to maturity.

#### *Fall Application to Winter Canola*

Apply up to 40 kg/ha (36 lb/acre) of nitrogen in the fall. If the land was fallow for one month or more before planting or if forage legumes were plowed down or manure was applied prior to planting, do not apply nitrogen fertilizer.

#### *Spring Application to Winter Canola*

The rate for spring application of nitrogen is based on the expected yield and on the price ratio between canola and nitrogen fertilizer. See Table 6–4, *Spring nitrogen guidelines for winter canola.*

**Table 6–3.** Nitrogen guidelines for spring canola

| Price Ratio[1] ($/kg N:$/kg canola) | Recommended N Rate (kg/ha) |
|---|---|
| 2 | 119 kg/ha |
| 2.5 | 108 kg/ha |
| 3 | 96 kg/ha |
| 3.3 | 90 kg/ha |
| 3.5 | 85 kg/ha |
| 4 | 74 kg/ha |

100 kg/ha = 90 lb/acre

[1] The price ratio is the cost of the nitrogen (N) in the fertilizer ($/kg N), divided by the selling price of the canola ($/kg of canola).
**Price Ratio Example**
Price of UAN is $350/t.
Price/kg N is $350 ÷ 280 = $1.25/kg.
Canola value at $420/t is $0.42/kg.
Price ratio is $1.25 ÷ $0.42 = 3
It takes 3 kg of canola to pay for 1 kg N.

**Table 6–4.** Spring nitrogen guidelines (most profitable N application) for winter canola

| Price Ratio[1] ($/kg N:$/kg canola) | Expected Yield | | |
|---|---|---|---|
| | 2 tonnes/ha (0.81 t/acre) | 3 tonnes/ha (1.21 t/acre) | 4 tonnes/ha (1.62 t/acre) |
| 3.3 | 125 kg N/ha | 170 kg N/ha | 195 kg N/ha |
| 2.5 | 160 kg N/ha | 195 kg N/ha | 210 kg N/ha |
| 2.0 | 180 kg N/ha | 210 kg N/ha | 220 kg N/ha |

100 kg/ha = 90 lb/acre
1 t/ha = 893 lb/acre or 44.1 bu/acre

[1] The price ratio is the cost of the nitrogen (N) in the fertilizer ($/kg N), divided by the selling price of the canola ($/kg of canola).
**Price Ratio Example**
Price of UAN is $350/t.
Price/kg N is $350 ÷ 280 = $1.25/kg.
Canola value at $420/t is $0.42/kg.
Price ratio is $1.25 ÷ $0.42 = 3
It takes 3 kg of canola to pay for 1 kg N.

## Phosphate and Potash

Phosphate and potash recommendations for canola are provided in Table 6–5, *Phosphate guidelines for canola* and Table 6–6, *Potash guidelines for canola,* based on OMAFRA-accredited soil tests. For information on the use of these Tables, or if a soil test is unavailable, see Chapter 9, Soil Fertility and Nutrient Use, *Fertilizer Guidelines.*

**Table 6–5.** Phosphate ($P_2O_5$) guidelines for canola

Based on OMAFRA-accredited soil tests.

Profitable response to applied nutrients occurs when the increase in crop value, from increased yield or quality, is greater than the cost of the applied nutrient.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure (Chapter 9, Manure section).

**Legend:** HR = high response, MR = medium response, LR = low response, RR = rare response, NR = no response

| Sodium Bicarbonate Phosphorus Soil Test | Phosphate Required |
|---|---|
| 0–3 ppm | 70 kg/ha (HR) |
| 4–5 ppm | 60 kg/ha (HR) |
| 6–7 ppm | 50 kg/ha (HR) |
| 8–9 ppm | 30 kg/ha (HR) |
| 10–12 ppm | 20 kg/ha (MR) |
| 13–15 ppm | 20 kg/ha (MR) |
| 16–30 ppm | 0 (LR) |
| 31–60 ppm | 0 (RR) |
| 61 ppm + | 0 (NR)[1] |

100 kg/ha = 90 lb/acre

[1] When the response rating for a nutrient is “NR,” application of phosphorus in fertilizer or manure may reduce crop yield or quality. For example, phosphorus applications may induce zinc deficiency on soils low in zinc and may increase the risk of water pollution.

## Phosphorus (P) Requirements

The phosphorus requirements of canola are greater than for cereals, due to the higher protein content of the seed. A 2.5 t/ha (1 ton/acre) canola crop will remove an average 53 kg/ha (48 lb/acre) of phosphate fertilizer ($P_20_5$ ) in the harvested seed. An additional 22 kg/ha (20 lb/acre) is taken up by the plant but recycled in the crop residue. Canola takes up phosphorus from the soil rapidly in the early growth stages and continues to remove phosphorus for up to about 8 weeks. Although canola requires a large amount of phosphorus, maximum yields are attained at generally lower rates than that for most spring cereals. The roots of canola will proliferate extensively in banded fertilizer phosphorus. Also, although canola is responsive to starter phosphorous it is also sensitive to salt injury, refer to Table 9–22, Chapter 9, *Maximum safe rates of nutrients in fertilizer.*

When applying phosphorus, an adequate supply near the seed row is important for early access. When broadcast, 2–4 times more P is required to obtain the same yield response as banded P, and broadcast P is also at higher risk for runoff. Canadian research indicates that canola yields are optimized with an initial 17–22 kg/ha (15–20 lb/acre) of starter $P_20_5$, even on soils with high fertility levels. Response to starter P is more likely on cold, low fertility soils, when planting early. Canola research has verified that MAP (11-52-0) is equally effective to other dry starters and liquid P fertilizer materials. The impact of starter fertilizer on early growth can be seen in Photo 6-4 where on a medium fertility level soil, the crop on the left side of the photo had no starter fertilizer applied, while on the right side of the photo the crop received 55 kg/ha (50 lb/acre) of MAP as a starter fertilizer at planting.

**Table 6–6.** Potash ($K_2O$) guidelines for canola

Based on OMAFRA-accredited soil tests.

Profitable response to applied nutrients occurs when the increase in crop value, from increased yield or quality, is greater than the cost of the applied nutrient.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure (Chapter 9, Manure section).

**Legend:** HR = high response, MR = medium response, LR = low response, RR = rare response, NR = no response

| Ammonium Acetate Potassium Soil Test | Potash Required |
|---|---|
| 0–15 ppm | 70 kg/ha (HR) |
| 16–30 ppm | 50 kg/ha (HR) |
| 31–45 ppm | 40 kg/ha (HR) |
| 46–60 ppm | 30 kg/ha (HR) |
| 61–80 ppm | 20 kg/ha (MR) |
| 81–100 ppm | 20 kg/ha (MR) |
| 101–120 ppm | 0 (LR) |
| 121–250 ppm | 0 (RR) |
| 251 ppm + | 0 (NR)[1] |

100 kg/ha = 90 lb/acre

[1] When the response rating for a nutrient is “NR,” application of potash in fertilizer or manure may reduce crop yield or quality. For example, potash applications may induce magnesium deficiency on soils low in magnesium.

**Photo 6–4.** The impact of early canola growth is evident for this medium fertility field, where the crop on the left side had no starter fertilizer applied while the crop on the right side the crop received 55 kg/ha (50 lbs/acre) of MAP at planting.

**Photo 6–5.** Sulphur deficiency, as seen in the canola plant on top, results in mottling of the leaf surface, purple underside of leaves and small, pale yellow flowers.

### Maximum Safe Rates of Seed-Placed Nutrients for Canola

Up to 28 kg/ha (25 lb/acre) of phosphate ($P_2 0_5$) may be seed-placed as ammoniated phosphate,or as superphosphate or MAP. Ensure the rate of nitrogen placed with the seed does not exceed 11 kg/ha (10 lb/acre).

The rate of nitrogen, potash ($K_2O$) and sulphur placed with the seed must not exceed 11–33 kg/ha (10–30 lb/acre) depending on soil type. The lower rate on sandy loam soils.

Ammonium sulphate has a high salt index and rates above 22 kg S/ha (20 lb S/acre) can reduce emergence, especially in dry conditions.

### Sulphur

Sulphur is linked to soil organic matter and is mobile, similar to nitrogen. Therefore deficiency is more likely to occur on sandy or open bottom soils with low organic matter. Canola has a much higher requirement for sulphur than most other field crops and sulphur deficiencies are becoming increasingly prevalent in canola due to higher crop yields and decreasing amounts received through acid rain deposition. A deficiency, shown in Photo 6–5 at the rosette stage, can occur at any crop stage and can reduce yields.

The current guideline is to apply up to 20 lb/acre of sulphur as an "insurance factor" against sulphur deficiency in canola. Applying 45 kg/ha (100 lb/acre) of ammonium sulphate (21-0-0-24) will supply the crop's sulphur needs and replace 23 kg/ha (50 lb/acre) of urea.

It is possible to apply sulphur to correct an observed deficiency with a broadcast application. Ideally all the required sulphur should be applied by the 6-leaf stage of the crop, when demands begin to increase rapidly, however applications up to the early flowering stage may provide a yield benefit where deficiencies exist. Effective absorption of sulphur occurs when foliar applications are made during the evening or early morning when temperatures are moderate, and under high humidity conditions.

### Boron

Boron deficiencies are rare in canola. Ontario field trials with foliar boron 0.34 kg/ha (0.3 lb/acre) applied at early flower did not show a consistent economic yield response. Although rarely seen, when it occurs it can reduce yields significantly. Symptoms can include:

- stunted appearance
- brown areas in pith of the stem or cracked stems
- brown to reddish coloured new leaves and yellow to brown spots in between the leaf veins
- cupping of leaves
- prolonged flowering and poor pollination

Boron deficiency can be corrected with either foliar or soil applications of soluble boron fertilizers.

### Plant Analysis

Tissue testing for diagnosing deficiencies is not well developed. Plant nutrient concentration is complicated by the plant age, plant part and level of crop stress. When canola is under stress, it may not be growing as quickly, but it will continue to take up nutrients. Tissue tests should be used along with a soil test to aid in interpreting results. For canola tissue tests, sample the youngest fully mature leaf. Table 6–7, *Interpretation of plant analysis for canola,* indicates normal ranges of plant analysis for canola.

**Table 6–7.** Interpretation of plant analysis for canola

Values apply to the top fully developed leaf prior to flowering. Note that as plants age, nutrient concentration tend to decline. Thus lower values of sufficiency range would be more applicable to young plants.

Reference values based on information from C.O. Plank and M.R. Tucker, 2000.

| Nutrient | Critical Concentration[1] | Sufficiency Range[2] |
|---|---|---|
| Nitrogen (N) | 3.6% | 4.0%–6.4% |
| Phosphorus (P) | 0.37% | 0.42%–0.69% |
| Potassium (K) | 2.15% | 3.5%–5.10% |
| Sulphur (S) | 0.47% | 0.65%–0.90% |
| Calcium (Ca) | 1.60% | 2.1%–3.0% |
| Magnesium (Mg) | 0.10% | 0.15%–0.62% |
| Boron (B) | 20.0 ppm | 25–54 ppm |
| Copper (Cu) | 4.0 ppm | 5–25 ppm |
| Manganese (Mn) | 20 ppm | 30–250 ppm |

[1] Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the “critical” concentration.
[2] Lower end of sufficiency range based on 100% relative yield.

## Harvest and Storage

Direct combining is the most common method of harvest in Ontario, although swathing is used in some areas. Direct combining usually results in improved seed quality compared to swathing, due to fewer fines and less green seed. Swathing may reduce shatter losses, and may be preferred on fields with uneven maturity. For more information on evaluating maturity and equipment settings for direct harvesting and swathing, see the *Managing Harvest* section of the *Canola Encyclopedia* publication developed by the Canola Council of Canada (www.canolacouncil.org).

### Direct Harvest

Direct combining is most successful when the crop ripens evenly, is heavy, relatively free of *Alternaria* disease, is partially lodged and well knit together. These conditions also reduce the risk of shattering and pod drop due to wind or driving rain. For direct-harvested canola, the crop is ripe when the pods are dry and rattle when shaken. There should be few green seeds, and seed moisture should be 10% or less. Harvest as soon as these conditions are reached because shatter losses increase the longer the mature crop stands in the field. If the crop maturity is uneven, the need for, and cost of using a desiccant should be evaluated versus swathing the crop. Seed oil content tends to be higher when a crop is direct harvested. Where the canola crop may be lodging or leaning, harvesting in the direction of the lean will reduce shatter losses significantly.

### Swathing

The optimum stage to swath canola is when 50%–60% of seeds on the main stem have changed colour. Farms with large areas of canola should start swathing at 30% colour change to ensure that the majority of acres can be swathed at near-optimum maturity without the risk of over-ripening, which leads to pod shattering.

In staging maturity, examine only those pods on the main stem. The pods at the bottom of a canola plant ripen first; therefore the pods at top may still be greenish when the field is ready for swathing. Do not let premature ripening caused by *Sclerotinia* or *Alternaria*, influence optimum staging to swath. Most of the crop yield will come from healthy plants. Pick a point at which the majority of the field is at the correct stage, ensuring that in less mature areas that seeds are green, firm and no longer translucent. Seed that does not ‘squish’ when rolled between fingers but is still green is adequately mature for swathing.

It often helps to swath when the crop is moist from dew or during a light drizzle. Leave the stubble tall enough, 25–30 cm (10–12 in.), to support the swath and anchor it in the field, and to minimize combine wear. Canola ripens and dries quickly in the swath. Usually 5–10 good drying days will lower the moisture so that seeds in the upper pods are firm. Under ideal drying conditions, canola seed can drop moisture quickly, therefore it is important to monitor moisture for ideal combining.

## Pre-Harvest Herbicides to Assist Canola Harvest

A pre-harvest herbicide application can facilitate direct harvest by speeding dry-down of canola plants. Use of the herbicide does not hasten maturity. Application can be helpful if the crop is uneven, reducing the risk of shattering in mature plants while waiting for immature areas to dry down. Harvest the field as soon as the crop is ready, as further dry-down increases risk of shattering loss.

Herbicides may also be used before harvest for weed control. Killing weeds can make harvest easier and reduce dockage. Glyphosate applied to Roundup-Ready canola will assist with dry-down of weeds but it will not help to dry down the crop. If winter wheat is planned and perennial weed pressure is high, a pre-harvest burn-down in canola may be the best option for weed control, since there isn't enough weed top growth for effective control after harvesting the canola.

## Combining Canola

The optimum time to harvest canola, directly or in swaths, is when there are few green seeds and seed moisture content is less than 10%. Depending on weather conditions, seeds rapidly lose moisture at 1%–3% or more per day. Do not delay harvest as seed losses from pod shattering increase dramatically about 10 days after optimum harvest timing. Shattering losses can be reduced by combining at higher seed moisture content and drying the crop, harvesting when there is dew or harvesting at night. Many operators start combining when the seed is slightly above 10% moisture.

Green seed issues occur when chlorophyll is not degraded or cleared from within the seed. Check harvested samples by crushing seeds on a strip of paper and determining the percent of distinctly green seeds. No. 1 and No. 2 Canada canola grades may contain a maximum of 2.0% and 6.0% of green seeds, respectively. Hot or windy weather can result in seed moisture content that indicates it is harvest ready, before there has been sufficient time for green chlorophyll to disappear. Several dews or a light rain can help to clear the green colour from seed.

When harvesting canola swaths, adjust the pick-up speed and height so the pick-up runs just under the swath and it is gently lifted. Also, slowing down the combine travel speed can dramatically reduce harvest losses. Monitor and make adjustments throughout the day to minimize harvest losses. 54 seeds/$m^2$ (5 seeds/$ft^2$) on the ground equates to a loss of 1 kg/ha (0.9 lb/acre). Average harvest losses range from 10–50 kg/ha (9–45 lb/acre).

## Storage of Canola

Canola is dry at 10% moisture but for long-term storage, seed moisture should be 8%–9%. The small seed size and high oil content results in rapid heating of stored canola. Heating in storage causes 'heat damage seed' that has higher free fatty acids and rancidity problems. High free fatty acid levels in canola are a problem for crushers, and heated seed can cause load rejection.

Before storing canola, check for openings in bins to prevent leaks as canola will flow freely. Aerate canola immediately following harvest to reduce risk of heating and mould development. Freshly harvested canola has a high respiration rate for up to 6 weeks following harvest before becoming dormant and safe for storage. Aeration fans designed to condition cereals and other grains may not be adequate for canola because of its small seed size. It takes more than twice as long to move a cooling front through canola compared to wheat. Green material (dockage) in canola is typically 3%–4% higher in moisture and can cause hot spots in storage. Seed that is over 10% moisture must be dried within 1–2 weeks of harvest to avoid spoilage. The rate at which canola deteriorates in storage depends on storage temperature, relative humidity, seed moisture content, the storage time and initial seed quality (green seed, dockage, etc.). Monitor stored canola weekly.

For further information on drying, handling, and storage of canola refer to the info sheet 'Storage of Canola' on the Alberta Agriculture website (www.agric.gov.ab.ca).

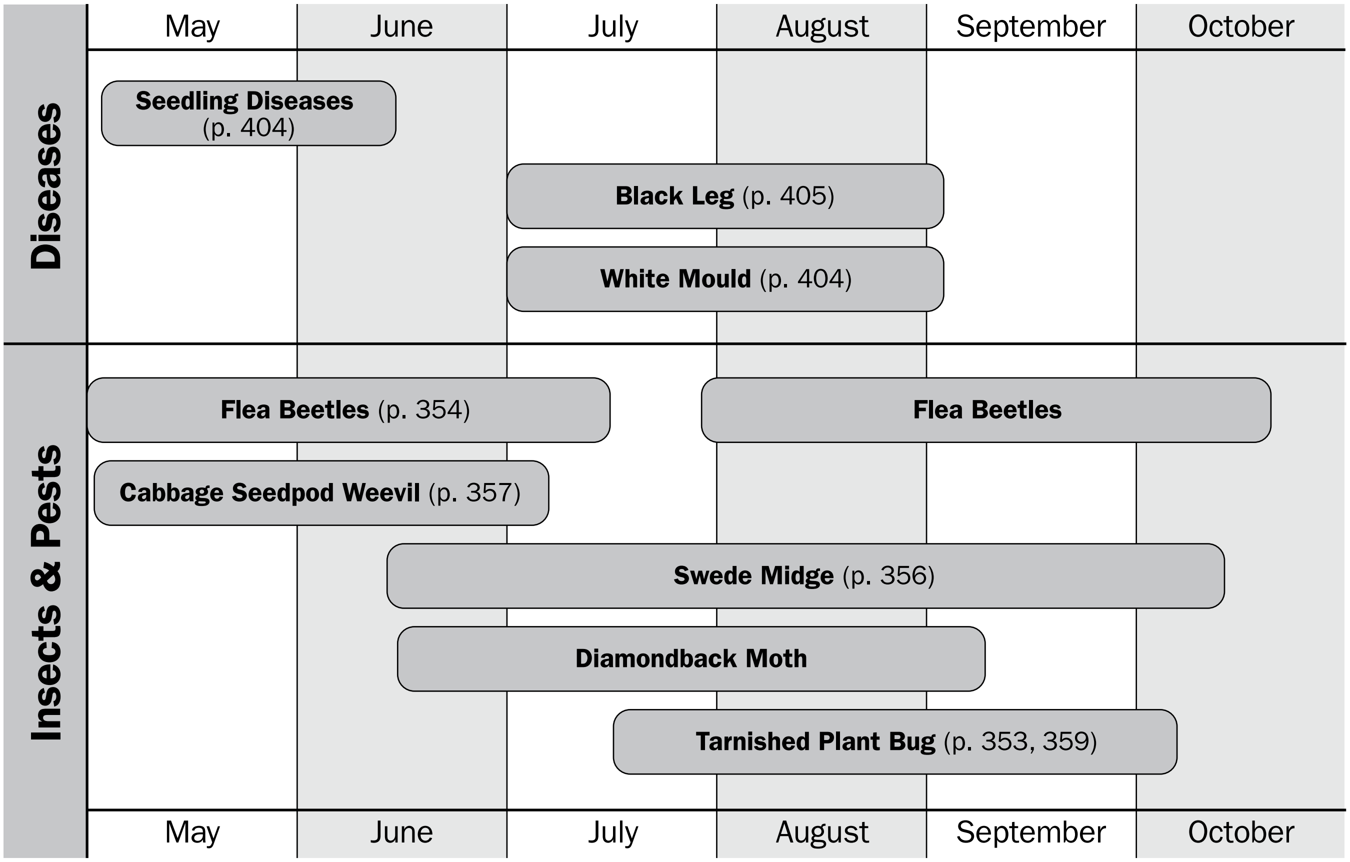


**Figure 6–1.** Canola scouting calendar.

## Other Crop Problems

### Insects and Diseases

Figure 6–1, *Canola scouting calendar,* shows insects and diseases that could cause symptoms in the field. Individual descriptions of insects and diseases, scouting and management strategies can be found in Chapter 15, *Insects and Pests of Field Crops*, and Chapter 16, *Diseases of Field Crops*.

Recommended treatments to control insects, pests and diseases can be found in OMAFRA Publication 812, *Field Crop Protection Guide*.

### Frost

Canola seedlings can recover from a light spring frost if the growing point is not damaged. Prior to taking any action, wait 4–5 days to assess damage. Check the growing point for green colour at the centre of the leaf rosettes. Although the cotyledons or other leaves may be black, re-growth can occur in 4–10 days depending on weather conditions if the growing point is alive. Photo 6–6 shows new growth from a seedling canola plant that has been affected by frost, but still has the growing point intact.

**Photo 6–6.** New growth from a canola seedling recovering from frost. Where the growing point is not damaged it will remain green.

Seedlings are more tolerant of frost at the 3–4 leaf stage than at the cotyledon stage. Ice crystals can form on the surface of plants without necessarily causing serious damage. Water within plant cells contains dissolved compounds that lower the freezing point by several degrees over water outside the cell. The length of time the plant is exposed to freezing temperatures is important, since a sharp frost that lasts only a short period may cause less damage than a mild frost that lasts all night. Rapidly growing plants are less tolerant of frost than plants that have undergone several days of cold weather (hardening).

Frost can be more damaging to canola that is in the flowering stage. Open flowers may be aborted and there may be a delay in maturity. While mature seeds under 20% moisture should remain unaffected by frost, developing seeds that experience a severe frost may not fill and can become shriveled. Check pods for damaged seeds that have lost their green colour and turgidity.

## Hail Damage

Plants will not usually survive if hail removes both cotyledons or the stem is broken below the cotyledons. However, because canola plants branch significantly in thin stands the yield loss may not be severely affected by the loss of plants. If hail occurs during vegetative growth and causes a loss of leaf area, yield will be reduced. Stem bruising and breakage will result in higher losses.

If hail occurs during flowering, plants can compensate by developing secondary clusters and new branches, refer to Table 6–8, *Percentage yield loss due to the destruction of branches during flowering in canola*. Yield losses will be highest when hail occurs during late flowering and during pod fill. Canola has poor ability to recover from hail once the pod-fill stage is reached. Hail between flowering and pod fill will result in uneven maturity due to a later flush of growth and flowers.

**Table 6–8.** Percentage yield loss due to the destruction of branches during flowering in canola

| % Branches Lost | Days From First Flower | | | | |
|---|---|---|---|---|---|
| | -7 | 0 | 7 | 14 | 21 |
| 10% | 0% | 0% | 10% | 10% | 10% |
| 20% | 0% | 0% | 13% | 20% | 20% |
| 30% | 0% | 0% | 12% | 29% | 30% |
| 40% | 0% | 0% | 12% | 32% | 40% |
| 50% | 0% | 0% | 14% | 36% | 50% |
| 60% | 0% | 0% | 18% | 42% | 60% |
| 70% | 0% | 0% | 24% | 50% | 70% |
| 80% | 0% | 5% | 31% | 60% | 80% |
| 90% | 0% | 12% | 40% | 71% | 90% |
| 100% | 0% | 20% | 51% | 84% | 100% |

Research conducted in Western Canada. Canola Council of Canada.

## Brown Seed (Heat Damaged)

Brown seed has been an occasional problem. Brown seed refers to the brown internal colour of the seed, as shown in Photo 6–7, when crushed and is caused by premature abortion of the developing cotyledons. Brown seeds are produced when canola is subjected to extended periods of high temperatures and moisture stress due to dry conditions during pod fill. Photo 6–8 shows heat blast in canola. High levels of brown-seed may make the crop unsuitable for processing for the food market, because of much higher free fatty acid (FFA) and phosphorus levels, which shorten the oil shelf life. There is limited research that suggests that brown seed is increased by insect feeding on developing seeds (e.g., tarnished plant bug, lygus bug and cabbage seedpod weevil). Registration of new varieties requires the FFA levels to be lower than those of current varieties.

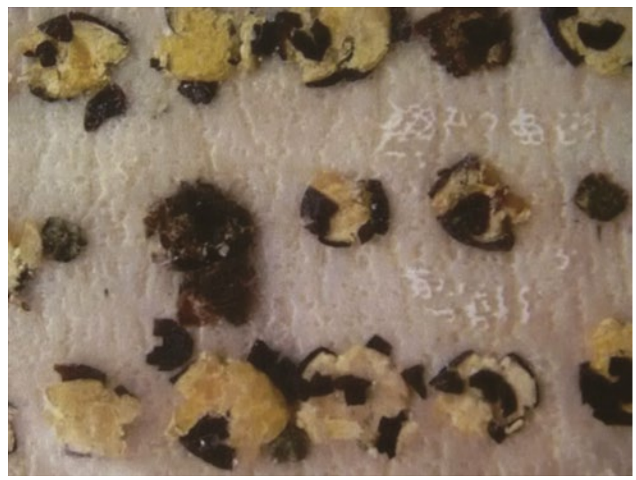

**Photo 6–7.** Brown heat damaged canola seed when crushed. Brown seed is caused by extended periods of high temperatures and moisture stress during pod fill.

## Temperature Stress (Heat Blast)

When stress from high temperatures (>28°C) occurs during the flowering period and the pod development period, the result is often abortion of flowers or pods. This is referred to as heat blast and can have a detrimental impact on yield (Photo 6–8). Spring varieties are often impacted more due to timing of flowering.

**Photo 6–8.** Heat blast. Hot temperatures during flowering (especially spring varieties) can cause heat blast and reduce seed yields.

## Green Seed

Green seed, or immature seed, is an important grade determinate and canola graded No. 1 Canada may contain a maximum of only 2% green seed. Green seeds levels are evaluated by determining the percent of seeds that are distinctly green when crushed. Green seed occurs when chlorophyll becomes “locked” in the seed at harvest. A sample strip is shown in Photo 6–7, where a few green seeds are visible. Causes include:

- early frost
- swathing or direct harvesting too early
- uneven crop maturity
- variety
- hot, very low humidity conditions during ripening

Natural plant enzymes break down chlorophyll as seeds mature. Air temperature and seed moisture are important in the breakdown of chlorophyll. When seed moisture drops below 20%, enzyme activity and seed respiration slows, reducing the rate at which green seed clears. A sub-lethal frost (about 0°C–10°C) can slow and even reverse the enzyme activity that breaks down chlorophyll. The main effect of a frost is a rapid dry-down of pods and seeds, before the chlorophyll has a chance to dissipate. Thin stands result in more branching of plants and an increase in variability in seed maturity. Green seed levels will not be reduced during storage at correct safe moisture levels (<10%).

## Winterkill

Winter canola is less winter-hardy than winter wheat in Ontario. Winterkill is most common in March and April after winter canola loses its winter hardiness, begins to grow and then is damaged by a return to extremely cold temperatures. Winterkill can also result from a lack of winter snow cover, prolonged periods of ice cover and desiccation by winter winds, resulting in weakened stands.

Heaving is an issue where there is not sufficient snow cover into late March/April. Frost heaving is caused by freeze-thaw cycles, occurring most often on poorly drained soils. Small plants that did not become adequately established lack the lateral roots necessary to anchor the plant against heaving. In saturated soils, freeze-thaw cycles can damage the top portion of the taproot, allowing root rot to invade. Plants that heave by more than 4 cm (1.5 in.) usually do not survive.

If the damage is severe enough, 75% kill, the crop may not be salvageable. However, if 30% of the stand remains, with healthy plants evenly distributed across the field, the crop will compensate sufficiently.

## Cross-Pollination

If varieties with different herbicide-resistant traits are allowed to cross-pollinate, it may result in volunteer canola plants with multiple resistance traits appearing in the subsequent crops. Fields planted to different types of herbicide-resistant varieties should be separated by a minimum of 175 m (575 ft). This isolation will reduce the occurrence of field-to-field cross-pollination. Research at Agriculture and Agri-Food Canada (AAFC), Swift Current, has indicated that pollination contamination was 2.1% at 46 m (150 ft), 1.1% at 137 m (450 ft) and 0.6% at 366 m (1,200 ft). A more recent study found that the first 100 m (330 ft) of an adjoining field contained about 99% of the unwanted pollen.