



Canola Growth, Development, and Fertility

WASHINGTON STATE UNIVERSITY EXTENSION FACT SHEET • FS045E

Synopsis

The purpose of this guide is to summarize current information on canola growth and fertilizer requirements. Canola is a relatively new crop to the Pacific Northwest and little fertility research has been conducted in this region. The information contained in this guide is intended to serve as a reference until the results of ongoing, local research are available. Canola is distinct from wheat in terms of growth habit, nutrient uptake, and nutrient removal in the seed. According to published research and fertilizer recommendations, canola requires more nitrogen and sulfur than wheat to achieve the same yields. Soil test-based requirements for phosphorus and potassium are similar to wheat, but boron requirements are higher. Because canola plant residue is higher in nitrogen and phosphorus than wheat straw, cycling of nutrients from residue to the subsequent crop may be an important rotational benefit of canola.

Canola growth and development

Canola stand establishment and seedling survival in the inland Pacific Northwest tends to be more variable than cereals. This is largely attributable to its “epigeal emergence” whereby the cotyledons and the shoot growing point emerge above the soil surface, increasing the plant’s exposure to environmental stress. In contrast, cereals exhibit “hypogeal emergence,” resulting in the shoot growing point remaining below ground and therefore more protected from extreme aerial climatic conditions. Seeding during favorable temperature and moisture conditions is therefore more critical for canola than for wheat stand establishment.

Canola also has an indeterminate growth habit. This means that individual plants are capable of expanding to utilize available space, water, and nutrient resources by increasing the length and number of lateral branches and pods per branch, and therefore seed yield. This largely explains why uneven stands of canola are still capable of producing high yields. In fact, canola is reported to be capable of producing near maximum yields with stand reductions of 50% or more (OMAFRA 2011).

Canola will continue to flower and develop seed until stress terminates these processes. Canola is more sensitive to heat stress at flowering than wheat since flowering and seed initiation occur over a long period of time, and a long duration of flowering is directly related to high seed yields. Collectively, the greater sensitivity of canola to environmental stresses at seedling establishment and at flowering accounts for higher yield variability with canola than with wheat.

Canola root systems exhibit typical taproot architecture shaped like an inverted cone where soil volume in contact with roots decreases with depth. Canola has an extensive root system (Weiss 1983) and root hairs (Hammac et al. 2011), which give it high root surface area and potential to remove nutrients from soil. The rooting depth for winter and spring canola has been reported as 65 and 46 inches, respectively (Johnston et al. 2002). However, Johnston et al. (2002) reported a deeper penetrating root system is often a response to limited water. In addition to nutrient uptake, canola’s root system provides stability against lodging (Goodman et al. 2001).

The proportion (%) of total aboveground plant dry matter that is seed (harvest index, HI) ranges from 20 to 35% for canola compared to a relatively stable average of 40% for wheat (Hocking and Stapper 2001, Hocking et al. 1997). Reported HI values vary widely in part because the date of planting and the timing of stress markedly affect seed yield, and many leaves senesce before maturity (Hocking et al. 1997, Major 1977). In Montana, Jackson (2000) also found spring canola returned about twice as much post-harvest residue to the soil as comparable yields of spring wheat.

Canola fertility

Canola follows dry matter and nitrogen (N) uptake patterns similar to wheat (Figure 1). Maximum dry matter and N accumulation occur between the beginning of stem elongation/branching and the end of flowering. Stress during this time will limit dry matter accumulation, N uptake, and seed yield by limiting lateral branching and flowering. Dry matter and N peak during seed fill and then

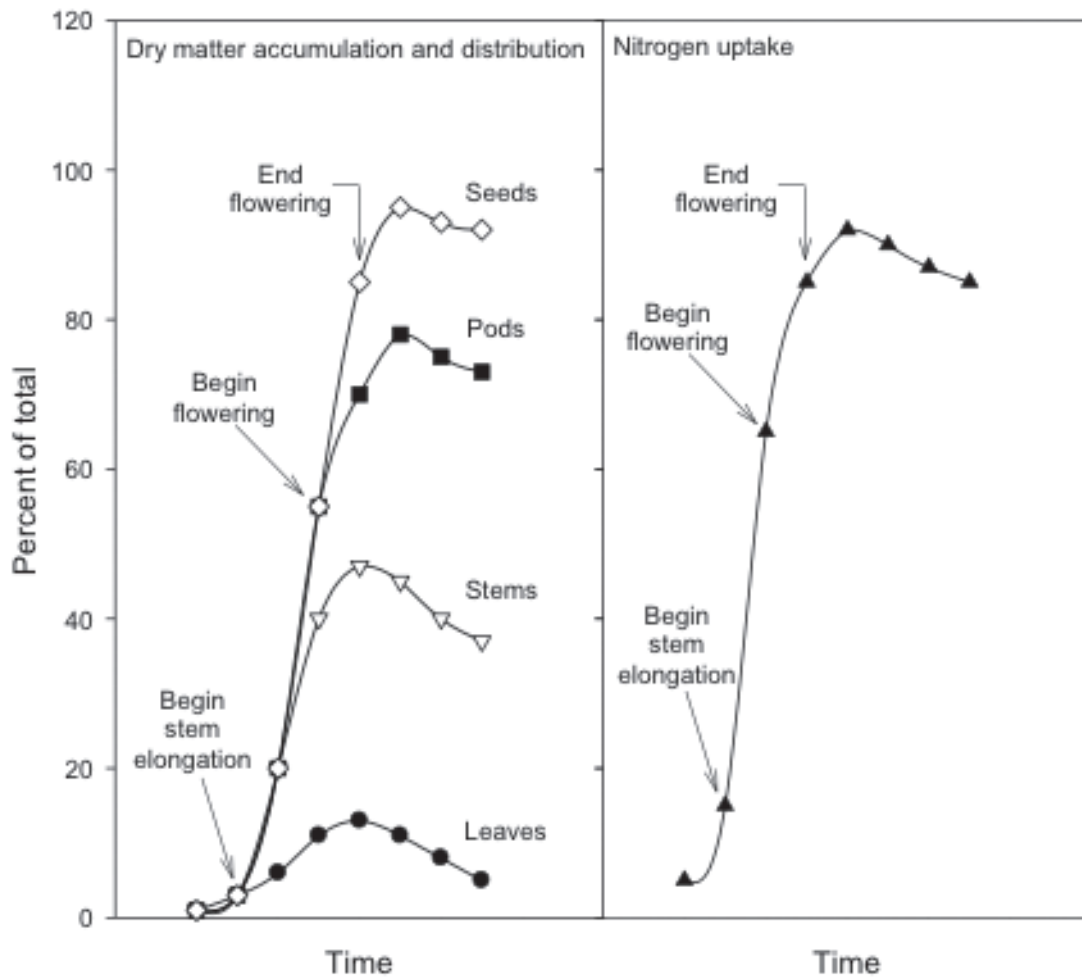


Figure 1. Generalized dry matter accumulation and distribution and nitrogen uptake patterns for canola. Adapted from Hocking and Stapper (2001), Hocking et al. (1997), and Major (1977).

decline as seed matures due primarily to leaf senescence and pod shattering.

Table 1 summarizes nutrient uptake, partitioning, and removal estimates for canola and wheat. On an equivalent yield basis, canola accumulates more nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) than wheat. Due in part to a low HI and high nutrient concentration in the residue, canola also leaves more nutrients in the field after harvest than comparable yields of wheat. For example, Jackson (2000) reported 40% of N, 30% of P, and 85% of K accumulated by spring canola remained in the residue left after harvest. Cycling of nutrients in this residue to subsequent crops is likely one important rotational benefit of canola (Kirkegaard et al. 1994, 1997).

The following sections discuss major nutrient responses, recommendations, and management for canola.

Nitrogen (N)

Canola seed yield responds well to applied N when residual soil levels are low (Grant and Bailey 1993, Hocking and Stapper 2001, Jackson 2000). In Montana, Jackson (2000) measured canola seed yield responses of 2,000 to 3,000 lb/acre when up to 225 lb N/acre was applied to soils with available N below 50 lb/acre. Similar yield responses were obtained when 90 lb N/acre was applied at a site with similar residual N levels in Australia (Hocking and Stapper

2001). A few references state that canola N requirements are similar to those of wheat, though most acknowledge that canola requires more N than an equivalent yield unit of wheat (Grant and Bailey 1993).

Gan et al. (2007) and Hammac et al. (2010) showed that canola had little or no yield response to N application when residual soil N was moderate to high. Similarly, grain N increases very little with an increasing N rate as maximum yield is approached. Nitrogen fertilization resulted in linear decreases in canola seed oil concentration (Jackson 2000, Ramsey and Callinan 1994, Sheppard and Bates 1980, Smith et al. 1988, Taylor et al. 1991). However, due to relatively larger seed yield responses to applied N, total oil yield still increased with N fertilizer up to rates that optimized yield. Excessive rates of N reduce seed yield due to lodging and delayed maturity (Grant and Bailey 1993, Jackson 2000, Sheppard and Bates 1980).

Table 2 summarizes base N recommendations for canola from several U.S. Extension fertilizer guides and one publication from Canada. Recommendations are similar to hard red spring wheat and higher than those commonly reported for soft white wheat in the Pacific Northwest. The formula for determining a canola N fertilizer recommendation is also similar to that of wheat:

$$\text{Fertilizer N recommendation} = (\text{yield goal} \times \text{base N recommendation}) - \text{soil N contributions}$$

Table 1. A comparison of average nutrient uptake and removal between canola and wheat.¹

| Nutrient | | Crop | | |
|--|-----------|---------------------------------------|--|---|
| | | Canola | Soft white winter wheat (10% protein) | Dark northern spring wheat (14% protein) |
| | | ————— lbs per 100 lb seed yield ————— | | |
| Nitrogen | Uptake | 5.8 | 2.2 | 3.2 |
| | Removal | 3.4 | 1.8 | 2.5 |
| | % Removed | 59 | 70 | 80 |
| Phosphorus (as P ₂ O ₅) | Uptake | 1.9 | 0.9 | 1.1 |
| | Removal | 1.3 | 0.7 | 0.9 |
| | % Removed | 68 | 80 | 80 |
| Potassium (as K ₂ O) | Uptake | 4.1 | 2.7 | 2.7 |
| | Removal | 0.6 | 0.6 | 0.6 |
| | % Removed | 15 | 22 | 22 |
| Sulfur | Uptake | 1.0 | 0.5 | 0.8 |
| | Removal | 0.6 | 0.2 | 0.3 |
| | % Removed | 60 | 40 | 40 |

¹ Source: USDA Plants Database, Nutrient Uptake Tool (<http://npk.nrcs.usda.gov/>), and Jackson (2000).

Table 2. A summary of base N requirements for canola from various U.S. states and Canada. For comparison, the soft white winter wheat base N recommendation is 4.5 lb/100 lb yield (2.7 lb N/bushel) and the dark northern spring wheat base N recommendation is 6.0 lb/100 lb yield (3.6 lb N/bushel).

| Source of recommendation | Winter canola | | Spring canola | |
|---|-------------------------------------|--|--------------------------|--|
| | ————— lbs N/100 lb seed yield ————— | | | |
| Colorado (San Luis Hills Farm 2007) | — | | 6 | |
| Great Plains Canola Handbook (Boyles et al. 2006) | 5 | | — | |
| Montana State University (Jackson 1999) | — | | 7 to 8 | |
| North Dakota State University (Fransen 1999) | 5 | | — | |
| Oregon State University (Wysocki et al. 2007) | 7 | | 7 | |
| Ontario, Canada (Alberta Agriculture 2002) | 5.9 to 11 ¹ | | 3.9 to 6.1 ¹ | |
| South Dakota State University (Boyles et al. 2006) | 6.5 | | 6.5 | |
| University of Idaho (Mahler and Guy 2002) | 8.1 to 10.7 ² | | 7.7 to 10.5 ² | |
| Washington (reported as “grower experiences” from 2 workshops held in 2000, Herdrich 2001) | 6 to 8 | | 6 to 8 | |

¹ Nitrogen recommendations depend on the yield level and fertilizer:canola price ratio. See Alberta Agriculture (2002) for details.

² Nitrogen recommendations depend on the yield level. See Mahler and Guy (2002) for details.

Soil N contributions include residual N in a soil test, organic matter contributions, and adjustments (credits or debits) based on previous crop history. These contributions can be estimated using established procedures for other crops.

Several studies have evaluated split applications of N for canola and rape. Wright et al. (1988) found no advantage with split applications of N made at sowing and rosette stages compared to similar rates applied only at sowing for spring rape in Australia. Similarly, Hocking and Stapper (2001) found no advantage with split applications of N made at sowing and stem elongation for spring canola. Nitrogen recommendations for winter canola grown in the United States (Boyles et al. 2006) state that low (< 1/3 total) rates of N should be applied in the fall to reduce the risk of winter injury.

Phosphorus (P)

Both research results (Bolland 1997, Grant and Bailey 1993) and Extension recommendations (Franzen 1999, Jackson 1999) suggest that canola is highly efficient at recovering P from soil and fertilizer sources. Canola has the ability to exude hydrogen ions (Hinsinger 2001) and organic compounds (Hocking 2001) such as citric and malic acids, which acidify the root zone and allow mineral P to become plant available. Research comparing the P requirements of canola and wheat in Australia showed that canola required 30 to 58% less P than wheat to maximize seed yield (Bolland 1997), though many states assume P recommendations are similar between canola and wheat (Alberta Agriculture 2002, San Luis Hills Farm 2007, Bolland 1997, Franzen 1999, Grant and Bailey 1993, Jackson 1999, Mahler and Guy 2002). Oilseed rape responded to up to 14 lb P₂O₅/acre when banded and 50 lb P₂O₅/acre when broadcast at low P-testing sites in Canada. Average soil test-based P recommendations for dryland canola are summarized in Table 3.

Starter applications of P are likely as efficient for canola as other crops. However, the amount of soluble N that can be placed along with P should be less than 5 lb/acre to prevent seed burning and emergence problems (Grant and Bailey 1993).

Table 3. Phosphorus fertilizer recommendations for dryland canola.

| Soil test P (ppm) 0 to 12-inch depth | | Application rate lb P ₂ O ₅ /acre ¹ |
|--------------------------------------|----------------------------|---|
| Acetate (Morgan) method | Bicarbonate (Olsen) method | |
| 0 to 2 | 0 to 4 | 30 |
| 2 to 4 | 4 to 8 | 20 |
| 4 to 6 | 8 to 12 | 10 |
| >6 | >12 | 0 |

¹These recommendations assume fertilizer is banded below the soil surface. For broadcast-incorporated applications, multiply the rates in this table by 2.

Potassium (K)

Canola accumulates relatively large amounts of K, but only a small portion of this is removed in the seed (Table 1; Jackson 2000). No response to applied K was observed with spring rape when soil test levels were approximately 60 mg/kg in Canada (Sheppard and Bates 1980). Grant and Bailey (1993) suggest K would only be required if exchangeable K levels in a soil test are well below 100 mg/kg, and likely as low as 35 mg/kg. Few U.S. Extension publications suggest the need to fertilize canola with K.

Sulfur (S)

Several authors emphasize the importance of S fertilization and that widespread occurrences of S deficiency are likely in canola-producing areas (Grant and Bailey 1993, Jackson 2000, Mahli et al. 2007, Nuttall and Ukrainetz 1991). Mahli et al. (2007) measured an average seed yield response of approximately 1000 lb/acre with various Brassica species in Canada when the soil test for SO₄-S (0 to 2 feet) was below 40 lb/acre. Jackson (2000) found spring canola responses to S fertilization (0 to 40 lb S/ac) of approximately 400 lb seed/acre even when the soil test for SO₄-S exceeded 100 lb/ac at the 0 to 2-foot depth. Nuttall and Ukrainetz (1991) found a linear reduction in seed yield with the time of S application after seeding, indicating the importance of S fertilization at or before seeding and not later. Jackson (2000) suggests S is necessary when a soil test for SO₄-S (0 to 2 feet) is below approximately 60 lb/acre in Montana. Grant and Bailey (1993) indicate a response to S can be expected when a soil test for SO₄-S (0 to 2 feet) is below approximately 28 lb/acre. Standard rates of S recommended in many U.S. Extension fertilizer guides range from 20 to 30 lb/acre.

Micronutrients

Few published reports were found where canola responses to micronutrients were evaluated. Grant and Bailey (1993), in a review of literature, suggest boron may be the most important micronutrient deficiency for canola. Requirements for copper and manganese are thought to be lower for canola than for cereals.

References

- Alberta Agriculture. 2002. *Alberta Fertilizer Guide*. Food and Rural Development, Agdex 541-1.
- Bolland, M.D.A. 1997. Comparative phosphorus requirement of canola and wheat. *Journal of Plant Nutrition* 20:813-829.
- Boyles, M., T. Peeper, and M. Stamm, eds. 2006. *Great Plains Canola Handbook*. MF-2734, Kansas State University, <http://www.oznet.ksu.edu/library/crpsl2/mf2734.pdf>.
- Franzen, D.W. 1999. Fertilizing Mustard and Canola. *North Dakota State University Extension SF-1122*, <http://www.ag.ndsu.edu/pubs/plantsci/soilfert/sf1122w.htm>.

- Gan, Y. S.S. Malhi, S. Brandt, F. Katepa-Mupondwa, and H.R. Kutcher. 2007. *Brassica juncea* Canola in the Northern Great Plains: Responses to Diverse Environments and Nitrogen Fertilization. *Agronomy Journal* 99:1208-1218.
- Goodman, A.M., M.J. Crook, and A.R. Ennos. 2001. Anchorage mechanisms of the tap root system of winter-sown oilseed rape (*Brassica napus* L.). *Annals of Botany* 87:397-404.
- Grant, C.A. and L.D. Bailey. 1993. Fertility management in canola production. *Canadian Journal of Plant Science* 73:651-670.
- Hammac, W.A., W.L. Pan, R.P. Bolton, and R.T. Koenig. 2011. High resolution imaging to assess oilseed species' root hair responses to soil water stress. *Plant and Soil* 339:125-135.
- Hammac, W.A., R.T. Koenig, and W.L. Pan. 2010. Nitrogen and Sulfur Fertility Effect On Pacific Northwest Dryland Canola (*Brassica napus*) Production. Soil Science Society of America International Conference—Oral Presentation. Long Beach, CA.
- Herdrich, N. 2001. Grower experiences with mustard and canola in eastern Washington, 1997-2000. *Washington State University Extension Publication EB1919*, <http://cru.cahe.wsu.edu/CEPublications/eb1919/eb1919.pdf>.
- Hinsinger, P. 2001. Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes: a review. *Plant and Soil* 237:173-195.
- Hocking, P.J. 2001. Organic acids exuded from roots in phosphorus uptake and aluminum tolerance of plants in acid soils. *Advances in Agronomy* 74:63-96.
- Hocking, P.J. and M. Stapper. 2001. Effects of sowing time and nitrogen fertilizer on canola and wheat, and nitrogen fertilizer on Indian mustard. I. Dry matter production, grain yield, and yield components. *Australian Journal of Agricultural Research* 52:623-634.
- Hocking, P.J., P.J. Randall, and D. DeMarco. 1997. The response of dryland canola to nitrogen fertilizer: partitioning and mobilization of dry matter and nitrogen, and nitrogen effects on yield components. *Field Crops Research* 54:201-220.
- Jackson, G.D. 1999. Canola Nutrient Management. *Fertilizer Facts* #22. Montana State University, Bozeman.
- Jackson, G.D. 2000. Effects of nitrogen and sulfur on canola yield and nutrient uptake. *Agronomy Journal* 92:644-649.
- Johnston, A.M., D.L. Tanaka, P.R. Miller, S.A. Brandt, D.C. Nielsen, G.P. Lafond, and N.R. Riveland. 2002. Oilseed crops for semiarid cropping systems in the Northern Great Plains. *Agronomy Journal* 94:231-240.
- Kirkegaard, J.A., P.A. Gardner, J.F. Angus, and E. Koetz. 1994. Effects of Brassica break crops on the growth and yield of wheat. *Australian Journal of Agricultural Research* 45:529-545.
- Kirkegaard, J.A., P.J. Hocking, J.F. Angus, G.N. Howe, and P.A. Gardner. 1997. Comparison of canola, Indian mustard and linola in two contrasting environments. II. Break-crop and nitrogen effects on subsequent wheat crops. *Field Crops Research* 52:179-191.
- Mahler, R.L. and S.O. Guy. 2002. *Northern Idaho Fertilizer Guide: Spring Canola*. University of Idaho Extension CIS 1012.
- Mahli, S.S., Y. Gan, and J.P. Raney. 2007. Yield, seed quality, and sulfur uptake of Brassica oilseed crops in response to sulfur fertilization. *Agronomy Journal* 99:570-577.
- Major, D.J. 1977. Analysis of growth of irrigated rape. *Canadian Journal of Plant Science* 57:193-197.
- Nuttall, W.F., and H. Ukrainetz. 1991. The effect of time of S application on yield and sulphur uptake of canola. *Communication in Soil Science and Plant Analysis* 22:269-281.
- OMAFRA. 2011. Spring and winter canola: fertility management. In: *Agronomy Guide for Field Crops, Pub. 811*. Ontario Ministry of Agriculture, Food and Rural Affairs, <http://www.omafra.gov.on.ca/english/crops/pub811/6fertility.htm>.
- Nyborg, M. and A.M.F. Hennig. 1969. Field experiments with different placements of fertilizers for barley, flax and rapeseed. *Canadian Journal of Soil Science* 49:79-88.
- Ramsey, B.R. and A.P.L. Callinan. 1994. Effects of nitrogen fertilizer on canola production in north central Victoria. *Australian Journal of Experimental Agriculture* 34:789-796.
- San Luis Hills Farm. 2007. Fertilization of Spring Canola. Fort Garland, Colorado, <http://www.slhfarm.com/canola-recs.html>.
- Sheppard, S.C. and T.E. Bates. 1980. Yield and chemical composition of rape in response to nitrogen, phosphorus and potassium. *Canadian Journal of Soil Science* 60:153-162.
- Smith, C.J., G.C. Wright, and M.R. Woodroffe. 1988. The effect of irrigation and nitrogen fertilizer on rapeseed (*Brassica napus*) production in south-eastern Australia. II. Nitrogen accumulation and oil yield. *Irrigation Science* 9:15-25.
- Taylor, A.J., C.J. Smith, and I.B. Wilson. 1991. Effect of irrigation and nitrogen fertilizer on yield, oil content, nitrogen accumulation and water use of canola (*Brassica napus* L.). *Nutrient Cycling in Agroecosystems* 29:249-260.
- Weiss, E.A. 1983. Rapeseed. In: G. Wrigley, ed. *Oilseed Crops*, pp. 161-215. New York: Longman Inc.

Wright, G.C., C.J. Smith, and M.R. Woodroffe. 1988. The effect of irrigation and nitrogen fertilizer on rapeseed (*Brassica napus*) production in south-eastern Australia. I. Growth and seed yield. *Irrigation Science* 9:1-13.

Wysocki, D.J., M. Corp, D.A. Horneck, and L.K. Lutcher. 2007. Nutrient Management Guide: Irrigated and Dry-land Canola. *Oregon State University EM-8943-E*, <http://extension.oregonstate.edu/catalog/pdf/em/em8943-e.pdf>.



By **Richard T. Koenig**, **W. Ashley Hammac**, and **William L. Pan**, Washington State University Department of Crop and Soil Sciences.

Copyright 2011 Washington State University

WSU Extension bulletins contain material written and produced for public distribution. Alternate formats of our educational materials are available upon request for persons with disabilities. Please contact Washington State University Extension for more information.

You may order copies of this and other publications from WSU Extension at 1-800-723-1763 or <http://pubs.wsu.edu>.

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published November 2011.