Camelina

Camelina, or false flax, is a new oilseed crop for the prairies that has been garnering a lot of attention over the past few years. This is partly due to a worldwide interest in bio-fuels. Other possible bio-based products from camelina include equine and fish feed, bio-lubricants and healthy dietary oil. Most recently, the jet fuel market has emerged as a potential business opportunity for camelina oil and, therefore, for camelina producers.

Camelina is well adapted to Saskatchewan growing conditions. It is highly tolerant of heat and drought, is shatter resistant and matures relatively early, making it suitable for warm and dry regions of Saskatchewan.

In February 2009, the United States Food and Drug Administration (US-FDA) allowed an interim exception for the limited use of camelina meal as a feed ingredient in feedlot beef cattle and growing swine rations. The US-FDA has also expressed no objection to feeding camelina meal to broiler chickens and laying hens up to 10 per cent of their final diet. In 2015, the Canadian Food Inspection Agency approved 12 per cent inclusion of cold-pressed non-solvent extracted camelina meal to broiler chicken feed. Approval for inclusion in layer feed is being considered.

In early 2010, Health Canada approved camelina oil as a novel food in Canada that would allow the sale of camelina oil into the human food market.

Plant description and adaptation

Camelina sativa (L.) Crantz., like canola and mustard, is a member of the Brassicaceae family. Camelina is also commonly referred to as false flax due to the similarity in pods/bolls. It originated in the Mediterranean-Central Asian region. It is an annual or winter annual that grows up to 90 cm tall and has branched smooth or hairy woody stems. Leaves are arrow-shaped, sharp-pointed and five to eight cm long with smooth edges. The flowers are small, pale or greenish-yellow with four petals and predominantly self-pollinated. The pear-like seed pods (siliques) are six to 14 mm long, holding eight to 10 yellow or brownish-yellow seeds. The seeds are small (one-quarter to one-half the size of canola), pale yellow-brown, oblong and rough, with a ridged surface.

Camelina is a short-season (85 to 100 days) crop with good drought and heat tolerance, cold tolerance and pod-shattering resistance characteristics, making it a viable oilseed crop for Saskatchewan, particularly the drier south-western region. It can grow on a wide range of soil types, and is responsive to fertilizer applications similar to canola and mustard.

Like rapeseed oil, camelina oil has been used as an industrial oil since the industrial revolution. The seeds were fed to caged birds and the straw used for fibre. Camelina has been evaluated to some extent in Canada (Downey, 1971) and to a larger extent in Minnesota (Robinson, 1987). However, there has been relatively little research conducted on this crop worldwide, and its full agronomic and breeding potential remains largely unexplored.

Seed composition, oil content and meal quality

Camelina has a unique oil profile that has generated interest among end-users in the cosmetics and human nutrition industries. In addition to being a good source of Omega-3 and Omega-6 fatty acids, it has the potential for use as a feedstock in the biodiesel industry, with the meal suitable as feed for poultry, cattle, hog and fish. Omega-3 and Omega-6 fatty acids are promoted by the health food industry to help lower high blood pressure, cholesterol and heart disease. Camelina seed oil has some properties (e.g. low viscosity) that would make it a desirable constituent in oil blends. Studies conducted by Agriculture and Agri-Food Canada (AAFC) on the Prairies show that the oil and protein content of camelina accessions ranged from 38 to 43 per cent and 27 to 32 per cent, respectively. A high variation in fatty acid compositions was observed. The most abundant

fatty acids were oleic (12.8 to14.7 per cent), linoleic (16.3 to17.2 per cent), alpha-linolenic (36.2 to 39.4 per cent) and eicosenoic (14 to15.5 per cent).

Fatty acid composition and use of the oil

The fatty acids in camelina oil are primarily unsaturated, with only about 12 per cent being saturated. About 54 per cent of the fatty acids are polyunsaturated, primarily linoleic (18:2) and alpha-linolenic (18:3), and 34 per cent are monounsaturated, primarily oleic (18:1) and eicosenoic (20:1). Due to its low saturated fat content, camelina oil could be considered high-quality edible oil. It is also quite highly polyunsaturated, making it susceptible to autoxidation and giving it a shorter shelf life. However, the presence of antioxidants such as tocopherols allows camelina oil to have a better shelf life than flax oil. Camelina oil has been used as a replacement for petroleum oil in pesticide sprays. The erucic acid content is about two to four per cent, which is greater than the maximum limits for canola-quality edible oil. Some studies have identified germplasm with zero erucic acid content, indicating that this trait could readily be removed through plant breeding, as it has been with canola.

Yield potential

Camelina crop at the vegetative/pre-bolting stage.

Studies in Saskatchewan (Gugel and Falk, 2006) showed that camelina yields are comparable to those of other Brassica species (*B. rapa*, *B. juncea* and *B. napus*). Camelina yields tend to be lower than the other species under adequate precipitation conditions. However, camelina out-yielded other Brassica species when moisture was limiting or untimely. Seed yield of the accessions tested ranged from 1,638 to 3,106 kg/ha over two locations in the Saskatoon area. In Alberta, camelina seed yield ranged from 1,987 to 3,320 kg/ha over two locations near Beaverlodge. In the Maritimes, seed yield ranged from 1,096 to 1,660 kg/ha over two locations and two seasons (Urbaniak et al., 2008). Research also confirmed that camelina performs very poorly under waterlogged conditions. Severe early season water logging led to a 27 to 32 per cent loss of plant stand at harvest (Gesch and Archer, 2009). Camelina needs well-aerated soils to obtain profitable yields.

Seeding

Camelina can be seeded as soon as the soil is workable, giving it an advantage over spring-germinating weeds. It requires no special equipment for seeding, although, due to the small-sized seed, adjustments are needed when handling camelina and good seed-to-soil contact is important. Under favourable conditions, experienced camelina producers in Saskatchewan successfully planted by broadcasting camelina seed with a Valmar spreader followed by heavy harrowing and rolling to obtain good seed-soil contact. An air seeder also works well, as long as it is seeded at a depth of no more than one-quarter inch. The seeding depth should be consistent and as shallow as possible. Some refer to optimum seeding depth as "just scratched in." The practice of broadcasting camelina seed on frozen ground in late November or early December was studied and found to be viable (Robinson, 1987). A winter-sown stand of camelina emerges before spring-sown crops and before significant weed flushes.

Seeding rate is also important as seed yield, maturity and competition with weeds are highly dependent on the plant stand. Preliminary results from an AAFC study in Saskatchewan shows that the optimum plant density should be about 210 plants/m^2 (20 plants/$ft.^2$). Results show that on the Prairies, average emergence is about 42 per cent. To achieve this plant population, the target seeding rate is about 500 seeds/m^2 (about

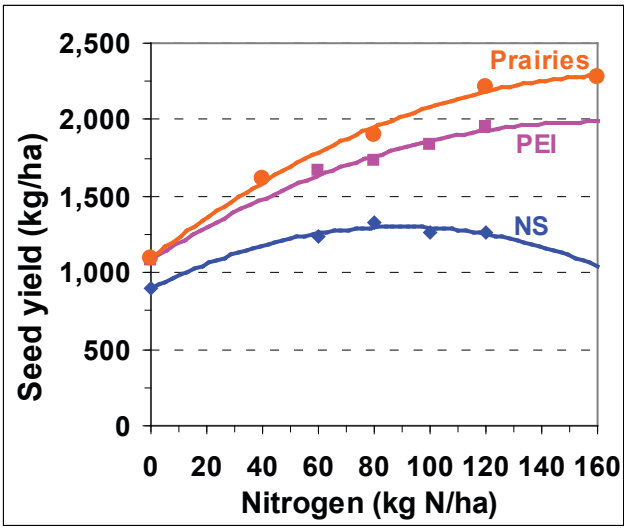
45 seeds/ft.^{2}). Considering an average thousand kernel weight (TKW) of 1.3 g, this works to a seeding rate of about 6 kg/ha (5 lb./ac). Seed yield did not change significantly beyond this rate. This seeding rate is consistent with practices used in the northern United States.

Research plots with 0 N/ha in the middle, 125 N/ha on the left and 75 N/ha on the right.

Camelina seeds can germinate at temperatures as low as 1 C, and young plants show resistance to frost up to -10 C during nights. This cold tolerance facilitates fall seeding and early spring seeding. Research on the optimum seeding dates for camelina was started in Saskatchewan in 2007 and is continuing at Indian Head, Swift Current and Scott. Preliminary results suggest that fall-seeded camelina may germinate in the fall and the seedlings will survive the harsh winter. These plants have a head start in spring and normally complete flowering by mid-July. So far, research results look promising for fall seeding and early spring seeding; however, it may not be suitable for all regions and all farms in Saskatchewan. Further investigation is still needed.

Nutrient requirements

The soil nutrient requirements of camelina are similar to those of other Brassica crops with the same yield potential. Camelina has been shown to respond to nitrogen (N) similarly to mustard or flax. However, it can yield well with lower nutrient inputs. In the Maritimes, research observed no yield increases beyond 60 kg N/ha in Nova Scotia (Urbaniak et al., 2008). While at a site in Prince Edward Island yield increases were observed up to 120 kg N/ha, seed yield increases beyond 80 kg N/ha were not significant. At four locations on the Prairies (Scott, Melfort, Lethbrige and Swift Current), AAFC scientists observed increasing yields up to the 120 kg N/ha rate with no significant increase beyond that. In Oregon, no increases in yield were observed beyond 50 kg N/ha (Ehrensing and Guy, 2008). Research clearly demonstrates that the fertilizer requirement and response in camelina varies with soil and growing conditions. Other nutrient requirements for camelina are similar to those of other Brassica species. However, more studies on other nutrient requirements on the prairies are needed.



Camelina seed yield response to N fertilizer rate at four locations on the prairies (Johnson et al. 2009) and one location each in Prince Edward Island (PEI) and Nova Scotia (NS) (Urbaniak, et al. 2008).

Producers should remember that while camelina is considered a low-input crop, it is not a zero-input crop. Lack of fertility combined with poor soil conditions could result in failure of the crop.

Weed control

Assure II herbicide (quizalofop-P ethyl) registration was pursued under the User Requested Minor-Use Label Expansion (URMULE) Program. The Pest Management Regulatory Agency (PMRA) completed the evaluation in June 2010 and later granted registration for the crop. Currently, Assure II (at variable rates) is registered to control several grassy weeds in the registered crops.

The Assure II product label is currently being developed to provide directions for proper use and may not be used until the label is approved by PMRA. Researchers at AAFC have

tested a few broadleaf herbicides known to control weeds in other Brassica species. No broadleaf weed control herbicides have been found suitable for camelina. Therefore, in-crop control of broadleaf weeds could be a serious issue.

The most effective weed control measure is early seeding, particularly fall seeding as it gives the crop a competitive advantage. Camelina seedlings are fairly small and non-competitive, but the early-emerging and cold-tolerant characteristic, especially when planted at high densities, provides excellent competition with many annual weeds. Perennial or biennial weeds are likely to be more difficult to control in camelina. However, the competitiveness of camelina with annual weeds presents the possibility that camelina could be grown both without tillage and without pre-emergence weed control. Camelina has been shown to be allelopathic. In summary, the most effective weed-control measure is seeding into a clean field. Weed control in the previous crop or in fallow is important for the success of growing camelina.

Diseases

Camelina is generally considered to be a disease-resistant crop. It is resistant to some of the common pests and diseases of Brassica oilseeds. The greater resistance of camelina is attributed to the production of antimicrobial compounds in the roots, including two phytoanticipins and the phytoalexins camalexin and methoxycamalexin. Camelina is considered to be resistant to alternaria blackspot. Research also suggests that Camelina sativa is highly resistant to a wide range of blackleg isolates (*Leptosphaeria maculans*).

Downy mildew on camelina.

Downy mildew

Downy mildew is a common disease of crucifer crops and is often associated with white rust. Downy mildew infection can be localized or systemic. Downy mildew on *Camelina sativa* is caused by *Perenospora parasitica*. This disease was most commonly noticed in Saskatchewan camelina fields. Symptoms on camelina include greyish-white mycelial growth on lower-leaf surfaces, stems and pods. Severely infected plants may be malformed. Researchers have found some resistance to this disease that would allow the development of downy mildew resistant cultivars in the future.

White rust 'staghead' on camelina. Photo courtesy of Agriculture and Agri-Food Canada.

Sclerotinia stem rot

Sclerotinia stem rot is caused by the fungus *Sclerotinia sclerotiorum*. Symptoms on camelina are similar to those on canola. Infection begins as a soft, watery rot on leaves or stems. Lesions develop up and down the stem from the point of infection, eventually girdling the stem and causing the plant to wilt and die. Research at AAFC Saskatoon revealed that the development of stem rot resistant cultivars is feasible.

White rust

White rust is caused by *Albugo candida*. It is a major disease of crucifer crops worldwide. Symptoms on camelina include powdery white pustules containing sporangia on lower leaf surfaces and hypertrophied siliques or entire inflorescences (staghead) that are conspicuous later in the growing season. Stagheads are green at first, but become brown and brittle at maturity. They contain thickwalled oospores that may survive in soil for several years before germinating to produce motile zoospores that infect cotyledons and rosette leaves.

White rust symptoms on camelina leaf. Photo courtesy of Agriculture and Agri-Food Canada.

Research results have shown that the isolate of *A. candida* from *C. sativa* was different from races two and seven, which are prevalent on Brassica crops in Western Canada. So far, no resistance to white rust has been observed in camelina germplasm.

Clubroot symptoms on camelina roots

Clubroot

Camelina was found to be highly susceptible to clubroot. Research trials in Alberta have revealed that the symptoms on camelina were typical to those observed on canola. To date, no resistance was found in camelina for clubroot disease. Therefore, this crop will not provide a viable rotation alternative in areas where clubroot is prevalent.

Aster yellows and downy mildew on camelina.

Aster yellows

Aster yellows is the most diverse and widespread phytoplasma disease worldwide. It was quite commonly observed in camelina trials. In Saskatoon, symptoms were first observed near the end of July and were severe by mid-August. Stems, leaves and siliques of plants exhibiting aster yellow symptoms were greenish-yellow or red, often with distorted inflorescences. Stunting was observed in most symptomatic plants. Small, flattened siliques containing small and misshapen seeds were observed on all infected plants. Small misshapen seeds were also observed in normal-looking siliques sampled from asymptomatic but infected plants. However, researchers have found some resistance in germplasm that could result in resistant cultivars.

Other diseases

Research trials have found other diseases on camelina such as damping-off and root rots caused by *Rhizoctonia solani* and *Pythium debaryanum*, grey mold caused by *Botrytis cinerea*, bacterial blight caused by *Pseudomonas syringae* and black rot caused by *Xanthomonas campestris*. Camelina was also found to be susceptible to viral diseases like turnip crinkle virus and turnip rosette virus that are transmitted by flea beetles.

In summary, camelina is highly resistant to alternaria black spot and blackleg of crucifers. It exhibits variation for resistance to sclerotinia stem rot, brown girdling root rot and downy mildew, suggesting that disease resistant cultivars can be developed. The susceptibility of camelina to clubroot, white rust and aster yellows disease will limit the utilization of this crop in areas where these diseases are prevalent.

Mature camelina pods.

Insects

Flea beetles [*Phyllotreta cruciferae* (Goeze)] may be observed on camelina, but the potential for damage is much less than that on canola, or even mustard. They have not been observed to cause appreciable damage to camelina in Montana or western Canada. To date, no damage due to any insect pests in camelina have been sufficient to warrant control measures.

Harvesting

Camelina is an early-maturing crop (85 to 100 days). Camelina can be direct combined or swathed and combined. It has been found to be more resistant to shattering than canola. Swathing has been found to be a suitable option and the crop holds well in the windrow. However, straight cutting is recommended due to potential damage from wind and because shattering losses are minimal. If swathing is necessary, swathing should be done when 75 per cent of the crop has turned yellow. Due to the small

seed size, caution needs to be exercised during threshing. Adjust combine speeds and wind flow appropriately to prevent seed loss. Thresh the crop at eight per cent seed moisture content. One bushel of camelina is equal to 50 lb. (22.7 kg).

Markets

Camelina is exclusively grown under contract. There is currently no open market for this crop. Therefore, it is recommended that producers contact camelina production contract companies, such as Smart Earth Seeds.

Other companies involved in camelina production include Terramax and Three Farmers.

For more information

Phone the Ministry of Agriculture's Provincial Specialist, Oilseed Crops, at 306-787-4668, or the Agriculture Knowledge Centre general inquiry line toll free at 1-866-457-2377.