7. Other Crops

BUCKWHEAT

Production Requirements

Soil Types: Prefers light to medium textured soils, but will grow in all soil types

Soil pH: 5.4–7.0

Preferred Rotational Crops: Corn, cereal crops

Should Not Rotate With: Soybeans, edible beans, canola or sunflowers

Minimum Soil Temperature: 7°C

Optimum Air Temperature: 12°C–25°C

Earliest Planting Date: After the risk of frost has past

Required Growing Season: 70–90 days from planting to maturity

Buckwheat is a fast-growing summer annual with broad, heart-shaped leaves and white flowers. It takes approximately 5–6 weeks from planting to first flower and 10–12 weeks from planting to harvest. Buckwheat is frost sensitive and is usually planted later than other field crops.

Buckwheat is used for human consumption, as an ingredient in livestock feeds and as a source for buckwheat honey. It is also commonly used as a cover crop for weed suppression and green manure, refer to Chapter 8, *Managing for Healthy Soils.* The grain of buckwheat has an amino acid composition that includes lysine, and thus provides a more complete protein compared to other cereals.

The most lucrative market is the export of quality, large-seeded buckwheat to the Pacific Rim countries, particularly Japan.

Tillage Options and Seedbed Preparation

Buckwheat is often planted in organic rotations and in unseeded acreage conditions where planting of corn or soybeans has been delayed beyond expectations of reaching maturity in remaining growing season. Buckwheat is also commonly used in abandoned fields and old pastures, to rejuvenate the fields prior to planting other crops. When preparing the seedbed, aim for effective weed control, moisture conservation and a firm seedbed. Weed control options in buckwheat are limited, so it is important to address weed control as much as possible before the crop is planted. Field preparation, in either fall or spring, could include an application of glyphosate prior to tillage to improve perennial weed control, or alternatively, spring secondary tillage could remove remaining perennials and stimulate annual weed growth. Repeating shallow tillage approximately every 7–14 days until seeding time will help minimize new weeds and conserve moisture.

Field Selection

Buckwheat is well adapted to the wide range of Ontario weather conditions. It is susceptible to late-spring and early-fall frosts. Buckwheat is sensitive to high temperatures and hot, dry winds, especially if these conditions occur during flowering seed-set. Buckwheat will grow on a wide range of soil types and is likely to produce a better crop on poor soil than any other grain crop. However, buckwheat prefers well-drained soils and is intolerant of severely dry, saturated or compacted soils.

Avoid fields that contain very high residual nitrogen, as this can increase crop lodging. The lush growth associated with these fields has often led to a higher incidence of white mould. White mould is a problem in soybeans, dry edible beans, canola, sunflowers and buckwheat. If possible, avoid fields where white mould has been a problem and plan the rotation to avoid a sequence of these crops.

In order to reduce volunteer grain when growing buckwheat for seed, avoid planting in fields where other grains were previously grown. This problem can be overcome by tilling in the fall and planting a winter cover crop that is incorporated in the spring before planting the buckwheat.

Variety Selection

If the crop is being grown for export markets, variety selection becomes important. The Japanese, North American and European markets demand large-seeded varieties for milling and de-hulling purposes.

New varieties tend to have larger seed size, along with increased bushel weight. These large-seeded varieties have larger leaves and, as a result, do not require higher seeding rates compared to the smaller-seeded types.

For seed sources, see *Cover Crop Seed Suppliers* on the OMAFRA website at ontario.ca/crops.

Planting

Buckwheat will germinate at temperatures from 7°C–40.5°C and will flower 5–6 weeks after planting. Buckwheat has an indeterminate growth habit, so the crop does not mature uniformly. Yields are highest if buckwheat is planted immediately after the risk of frost has passed. Early planting into conditions that are favourable for crop emergence helps minimize volunteer problems the following year. Traditionally, buckwheat was planted in mid-summer and often harvested after frost. Although this method avoided flowering during hot weather, immature seeds would drop and reduce yields, and potentially pose a severe volunteer problem for following crops.

Planting with a drill will produce a more uniform stand, but satisfactory results can also be obtained with broadcast seeding. Plant seeds at a depth of 4–6 cm (1.5–2.5 in.) into moisture to obtain rapid and uniform emergence. Seedlings should emerge in 2–5 days.

Recommended seeding rates for grain production are 50–65 kg/ha (45–60 lb/acre). This will achieve the ideal plant stand of 140–183 plants/m^2 (13–17 plants/ft^2).

When planting buckwheat as a green manure or cover crop, the optimum seeding rate ranges from 50–60 kg/ha (45–54 lb/acre). Higher seeding rates result in higher plant populations, producing a smothering effect to aid weed control. However, even if the stand is thin, the plant's ability to branch out will often compensate for thinner stands and will still result in good weed control.

As a Green Manure

Buckwheat has the ability to take up phosphate unavailable to other crops, thereby increasing the amount of phosphorus available to subsequent crops. To take advantage of its large biomass, incorporate or chemically control buckwheat between 4–7 weeks after planting, before the first seeds have set. If the field is left until full bloom, there is more likelihood of volunteer buckwheat problems the following year.

Fertility Management

Fertility requirements for buckwheat are similar to oats. Table 7–1, *Nitrogen requirements for buckwheat*, Table 7–2, *Phosphate guidelines for buckwheat and flax* and Table 7–3, *Potash guidelines for buckwheat and flax* display the suggested rates of nitrogen, phosphate and potash based on OMAFRA-accredited soil tests.

Table 7–1. Nitrogen requirements for buckwheat

Growing Region	Maximum Rate of Nitrogen for Buckwheat
Southern Ontario	35 kg/ha (30 lbs/acre)
Northern Ontario	55 kg/ha (50 lbs/acre)

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. See Chapter 9, Soil Fertility and Nutrient Use, Table 9–10, *Typical amounts of total and available nitrogen, phosphate and potash from various organic nutrient sources.*

Table 7–2. Phosphate (P_2O_5) guidelines for buckwheat and flax

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, phosphate applications may induce zinc deficiency on soils low in zinc and may increase the risk of water pollution.

Table 7–3. Potash (K_2O) Guidelines for buckwheat and flax

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 kg/ha (LR)
121–250 ppm	0 kg/ha (RR)
251 ppm +	0 kg/ha (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 application on soils low in magnesium may induce magnesium deficiency.

Harvest and Storage

Harvest

Buckwheat is an indeterminate plant. Flowers, green seed and mature seed are present on the plant at the same time. Flowering begins 5–6 weeks after sowing and continues for at least 1 month. Insects, honeybees and leafcutter bees are the main pollinating agents and are essential for good seed set. An arrangement with an apiarist will be of mutual benefit. Harvest must occur prior to the development of overripe seed. This will be approximately 10 weeks after planting, when the crop is still growing and flowering. At this stage, 70%–75% of the seeds should be brown, mature and not yet dropping from the bottom of the bloom spike. If harvest is delayed until the seeds nearest the ground begin to fall, yields will be decreased due to seed drop, and the volunteer population will cause problems for the next crop.

Yields will vary depending on pollination and weather conditions. Yields of 2.2 t/ha (40 bu/acre) are possible, but 1.1–1.6 t/ha (20–30 bu/acre) are more commonly reported.

Swathing

Swath the buckwheat ahead of harvest, if the crop has not been killed by frost. Do not desiccate buckwheat as desiccation weakens the stem and increases lodging. To minimize seed shatter, swath early in the morning when dew is present or in damp weather. Cut the buckwheat high, leaving stubble to facilitate drying.

Combining can occur when seed moisture reaches 16%. When combining, reduce the pick-up speed to match the ground speed to minimize shattering. The draper-type of pick-up causes less shattering than the drum-type. To minimize breakage, reduce the cylinder speed to one-third (600–800 rpm) of that used for cereal grains and set the concaves to approximately 13–16 cm (5.25–6.5 in.) in the front and 9 mm (0.38 in.) in the rear. The upper sieve is set at 16 mm (0.63 in.) and the lower sieve at 8 mm (0.3 in.). If seed is dehulling, increase the concave size or lower the cylinder speed. The lower sieve can then be opened gradually, to the setting that does not allow excess foreign material to pass through. Check that the wind blast is strong enough to remove the maximum amount of trash without blowing out clean grain.

Direct Combining

Direct combining is an option for late summer seeded crops that have been killed by frost. Wait 7–10 days after frost, keep ground speed low and cut stubble high to prevent overloading of the combine. To reduce breakage, pay attention to the amount of coarse material that is allowed to pass through so that only a minimum of seed enters the return.

Storage

Buckwheat can be safely stored at moisture levels under 16%. The longer buckwheat seed is stored the more oxidation that occurs resulting in the light green layer under the hull gradually changing to a reddish-brown colour. Oxidized seed is easily detected, and becomes significant for markets that prefer freshly harvested buckwheat (i.e., Japanese market). Do not store or mix seed from previous stored crops.

Livestock Feed

Buckwheat grain can be used as a livestock feed in a limited inclusion basis in the ration. Buckwheat grain can be up to one-third of the grain concentrate portion for a beef or dairy ration. Swine feeding research, with newer varieties of buckwheat, found that the overall performance of growing-finishing pigs fed buckwheat in the ration was comparable to pigs fed cereal grains.

Feeding Precaution

Feeding buckwheat fodder, whether fresh or dried, can have toxic effects. The primary effect is a photosensitization in animals with light-coloured skin (this includes cattle, goats, sheep, swine and turkey) exposed to the sun. Jaundice is a secondary toxic effect.

Weed Control

Weed control in buckwheat can be difficult and requires planning, as there are few herbicides available, particularly for broadleaf weed control. Buckwheat is sensitive to residual herbicides (e.g., triazine, sulfonylurea and trifluralin). Since buckwheat is often sown late, there is ample opportunity to control problem weeds with herbicides or cultivation before seeding.

Insects and Diseases

Buckwheat seldom has insect or disease concerns other than white mould.

CAMELINA

Production Requirements

Soil Types: Well-drained soils, light to medium textured soils

Soil pH: Acidic to alkaline soils

Preferred Rotational Crops: Cereals

Should Not Rotate With: Canola, dry edible beans, soybeans, sunflowers or buckwheat

Minimum Soil Temperature: Has been broadcast onto frozen ground in early December under no-till conditions

Optimum Air Temperature: 20°C–25°C

Earliest Planting Date: Frost tolerant, heat tolerant

Required Growing Season: 80–100 days (11–14 weeks)

Camelina is an excellent source of omega-3 and omega-6 essential fatty acids. The oil has been used in the formulation of cosmetics, skin creams and lotions. It is also used for biodiesel production and lubricants.

Planting

Camelina can be sown in late fall as a winter annual, or in spring. Fall seeding using no-till methods seems to work better than conventional tillage and seeding. Seed at 4–6 kg/ha (9–13 lb/acre) to achieve a stand of 400–600 plants/m^2 (37–56 plants/ft^2). Seed at a depth of 6.5 mm (0.25 in.). Seed size varies considerably between varieties. Adjust the planting rate according to both seed size and percent germination.

Fertility Management

Limited Ontario fertility guidelines exist. Suggested fertilizer rates would be similar to that for canola as camelina is a close relative. Phosphorus and potassium fertility should be at target soil test levels (12–18 ppm P and 100–130 ppm K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting at rates to meet the crop removal plus an amount that will build up the soil test over time. See Fertilizer Guidelines in Chapter 9, *Soil Fertility and Nutrient Use*.

Harvest and Storage

Harvest

Combine 80–100 days after planting when pods are brown. The seed is extremely small; about quarter to half the size of canola seed. (1,000 seed weight = 1 to 2 g, or approximately 666,000 seeds/kg or 300,000 seeds/lb).

Standard canola harvesting practices can be followed, although producers will need to fit combines with properly sized screens.

Storage

Store seed in dry areas (under 8% moisture) and at low relative humidity.

Insects and Diseases

Camelina seed can act as a vector for the transmission of Turnip Yellow Mosaic virus. Camelina shows resistance to blackleg *(Leptosphaeria maculans),* and to *Alternaria Brassicae.* To date the most significant pest in Ontario has been flea beetles. Pests of canola and other oilseeds in Ontario may affect camelina. For registered pesticides on this crop, always refer to product labels, and follow specified directions. For more information, go to ontario.ca/crops, search on Industrial Miscellaneous, then oil crops.

FLAX

Production Requirements

Soil Types: Well-drained loam, silt loam or clay loam soils are preferred

Soil pH: >5.6

Preferred Rotational Crops: Corn, cereal crops

Minimum Soil Temperature: 3°C

Optimum Air Temperature: 10°C–27°C

Earliest Planting Date: Early to late April

Required Growing Season: 90–115 days

Flax is a versatile crop that has been an ingredient in oil-based paints, protective coatings, linoleum, printer's ink, soaps, industrial lubricants and as a salt-resistant coating for concrete. Fibre flax and the health benefits of flaxseed oil in a variety of foods have diversified the market. Flax seed contains 35%–40% linseed oil. After oil extraction, the remaining linseed meal is used as a livestock protein supplement, which averages approximately 35% protein content.

The guidelines provided in this section refer to oilseed-type flax. Production requirements for fibre flax may be different. More information on fibre flax in Canada is available from the Flax Council of Canada website at www.flaxcouncil.ca.

Tillage and Seedbed Preparation

A firm, level seedbed for good seed-to-soil contact is best for rapid, uniform emergence. Packing the soil before and/or after planting is suggested. Crop success has been better where there is minimal crop residue. Use rotations similar to those for cereals or legume forages.

Variety Selection

Variety selection will be different for oilseed and fibre purposes. Until now, oilseed varieties have been the only commercially produced flax grown in Canada. Oilseed varieties are grown specifically for the oil extracted from the seed.

Planting

Flax is planted using similar equipment to cereals, in narrow rows 15–20 cm (6–8 in.) apart. Using a grain drill results in a more uniform seeding depth and plant emergence than broadcast seeding. Seed to a maximum depth of 2.5 cm (1 in.), as there is likely to be adequate soil moisture to stimulate germination in the spring. Deep seeding can significantly delay emergence, particularly during cool, wet springs. Optimum seeding rates are 35–50 kg/ha (31–45 lb/acre). Seeding rates higher than 50 kg/ha along with high nitrogen rates can lead to excessive lodging, making harvest difficult.

Early planting results in higher yields and easier harvest. Seedlings can withstand moderate frost. Well-drained loam, silt loam or clay loam soils are preferred. Flax plants have a relatively short taproot which makes plants susceptible to moisture stress on light textured soils.

Crop Development

Flax is an annual plant with a short taproot from which fibrous roots grow to depths of approximately 1.2 m (4 ft) in light soil. The height of the crop varies from 45–91 cm (1.5–3 ft), depending on growing conditions. In thick stands, only a main stem develops but in thin stands four or more tillers can be produced. Flowers may be white, blue, pink or violet, depending on variety. Flowers open late in the morning and drop by early afternoon. Flax flowers for 3 weeks with sufficient fertility. Flax flowers can self-pollinate, but insects can cross-pollinate between varieties. A seed capsule produces up to 10 seeds. Flax seed produces a gel around the seed once they are exposed to water. This gel gives the seed a sticky texture when wet which could make handling more difficult.

Fertility Management

Flax nitrogen needs are the same as for mixed grain (45 kg/ha or 40 lb/acre in southern Ontario and 70 kg/ha or 62 lb/acre in northern Ontario). Excessive nitrogen will make the crop lodge. A soil test is the best method of determining phosphorus and potassium requirements. See Table 7–2, *Phosphate guidelines for buckwheat and flax* and 7–3, *Potash guidelines for buckwheat and flax*. Flaxseed is susceptible to fertilizer burn; therefore, broadcast all fertilizer.

Harvest and Storage

Harvest

Flax typically yields 1,200–2,000 kg/ha (1,100–1,800 lb/acre). Flax can be harvested by either direct combining or by swathing prior to combining.

Direct Combining

Since flax will continue to produce new vegetation throughout the season, a pre-harvest dessicant will be required if the crop is being direct combined. When direct combining, use batt reels to prevent wrapping of flax plants with pick-up reels. Consult the product label for specific directions on pre-harvest applications.

Swathing

Swathing, then combining, results in drier seed than with direct combining. Swath when approximately 90% of leaves have fallen and the seeds have turned dark brown. Flax does not shatter as easily as other grains. Swath weedy crops to allow weeds and straw to dry out before harvest. Leave 15 cm (6 in.) of straw stubble to keep windrows off the ground. Under good drying conditions, the crop can be combined 3–4 days after swathing.

Keep combine and swather cutter bars and guards sharp to reduce the accumulation of immature flax straw on the knife. Combine flax when the straw is dry and seeds rattle in the boll. Early-sown flax is easier to thresh than late-sown flax because it matures under the dryer conditions of late summer.

Adjust the combine to narrow the clearance between the cylinders and concave to about half that of cereal grains and slow down the cylinder. Set fan speeds fairly low since seed is easily blown out the back of the combine. A clean-looking sample in the bin is an indication that too much seed is being blown out. It is not unusual to have dockage levels of 5%–10%. Be sure to plug any holes in the grain tank, augers and elevators, because flax seed is extremely slippery and will flow through small holes.

Storage

For storage, flax should be less than 10.5% moisture. Higher moisture percentages will incur a drying and shrinkage charge. Flax spoils quickly; therefore, proper storage is critical. Drying and cleaning prior to storage can help reduce the amount of dockage.

Straw Removal

Oilseed varieties of flax straw are not suitable for linen production due to the short fibres in the stem. Flax straw is slow to rot in the soil and is usually a problem for tillage operations following harvest or in the following crop season. Make every effort to find a use for the straw so that it can be taken off the field. Flax straw is sometimes used in feedlots as bedding. The straw has also been used as a fuel source for burning in large furnaces.

Weed Control

Flax is a poor competitor with weeds. It does not form a dense canopy to shade the ground, so weeds have the opportunity to establish. Perennial and difficult to control weeds are especially problematic since herbicide options are limited. Plant flax in relatively weed-free fields, whenever possible.

For herbicide options, see OMAFRA Publication 75, *Guide to Weed Control.*

Insects and Diseases

Insects and diseases are typically not a concern in flax production.

HEMP

Production Requirements

Soil Types: Prefers well drained soils. Reduced yields on extremely heavy or light textured soil types

Soil pH: 6.0–7.5

Recommended Rotational Crops: 4-year rotation with cereals or corn

Should not plant after: canola, edible beans, soybeans, buckwheat or sunflowers

Minimum Soil Temperature: 4°C–6°C (seedlings are sensitive to frost)

Optimum Air Temperature: 25°C–28°C

Earliest Planting Date: Early to late May

Required Growing Season: 70–90 days for fibre crops and 100–200 days for grain crops

Hemp *(Cannabis sativa)* is an annual crop grown for specialty grains, oils and personal care products. It can also be grown as industrial fibre for textiles, paper and biofuels markets. Currently grain is the main market for hemp in Ontario.

Industrial hemp is a controlled substance and may only be grown under license from Health Canada. Health Canada controls the importation, production, processing, possession, sale, transportation, delivery and offering for sale of industrial hemp. Only varieties named in the "List of Approved Cultivars" published by Health Canada are approved for planting. All industrial hemp grown, processed, and sold in Canada must contain 0.3% tetrahydrocannabinol (THC) or less in the leaves and flowering parts. In addition a maximum level of 10 parts per million (ppm) for THC residues in products derived from hemp grain, such as flour and oil has been set under the regulation. Information about varieties, licenses and regulations may be obtained by contacting Health Canada's Office of Controlled Substances or hemp@hc-sc.gc.ca.

Description

Different cultivars are grown for fibre and seed. When grown as a fibre crop, hemp grows to a height of 1.5–3 m (5–10 ft) without branching. In dense plantings, the bottom leaves atrophy due to the exclusion of sunlight. The stem has an outer bark which contains the long, tough bast fibres for which hemp is renowned. The centre core contains the hurds, or short fibres, that are useful in many other applications such as animal bedding.

Soil Conditions

Hemp responds to a well-drained, sandy loam soil with a pH range of 6.0–7.5.

The higher the clay content of the soil, the lower the tonnage of fibre that will be produced. Clay soils are easily compacted, and hemp is very sensitive to soil compaction. In well-structured and well-drained soils, the tap root may penetrate 15–30 cm (6–12 in.) deep. In compacted soils the tap root remains short and the plant produces more lateral fibrous roots.

Tillage and Seedbed Preparation

Hemp seed requires good seed-to-soil contact. The seedbed should be firm, level and relatively fine, similar to that prepared for direct-seeded forages. The soil can be worked and planted as soon as the ground is dry enough to avoid compaction.

Planting

Plant seed in 15–18 cm (6–7 in.) row spacing at a depth of 3 cm (1.25 in.). The optimum soil temperature for rapid germination is 8°C–10°C, although hemp seed will germinate at 4°C–6°C. Early planting produces taller plants with higher fibre yields. The optimum final population for fibre production is about 200–250 plants/m^2 (19–23 plants/ft^2 or 810,000–1,000,000 plants/acre). For seed or grain production, the optimum final plant population is around 100–150 plants/m^2 (9–14 plants/ft^2 or (400,000–610,000 plants/acre).

Hemp is a heavy user of moisture; therefore, it is important to make use of early soil moisture and to obtain a good ground cover early to reduce surface evaporation. For grain production, about half of this moisture is required during flowering and seed set.

Seedling plants can tolerate a light frost and will continue to grow at temperatures as low as 2°C. After the third pair of leaves has developed, hemp has been known to survive temperatures as low as -5°C for 4–5 days. During vegetative growth, hemp responds to daytime high temperatures in the range of 25°C–28°C.

Fertility Management

Limited Ontario fertility guidelines exist. Hemp requires approximately the same fertility as a high-yielding crop of wheat. Research is continuing to fine-tune exact nutrient requirements. Apply up to 110 kg/ha (98 lb/acre) of nitrogen, depending on soil fertility and past cropping history. Phosphorus and potash fertility should be at target soil test levels (12–18 ppm P and 100–130 ppm K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting, at rates that meet the crop removal rate plus an amount that will build up the soil test over time. See *Fertilizer Guidelines,* Chapter 9, *Soil Fertility and Nutrient Use.*

Weed Control

If hemp is planted in well-drained, fertile soil under nearly optimum temperature and moisture conditions, it will germinate quickly and reach 30 cm (1 ft) in 28–35 days from planting. At this stage it will give 90% ground shade and weed growth suppression by the exclusion of light from the soil. Under rapid growing conditions, hemp at a final population of 200–250 plants/m^2 will suppress nearly all weed growth for that season. For more information, see OMAFRA Publication 75, *Guide to Weed Control.*

Harvest and Storage

Harvest

Harvest depends on end use:

- **Textile fibre:** harvest at flowering after pollen shed but before seed set, approximately 70–90 days after seeding.
- **Industrial fibre:** harvest any time after flowering. Hemp fibre that is cut after seed harvest has lignified considerably and is only usable in coarse industrial fibre applications.
- **For fibre:** when harvested using standard field-crop equipment including sickle mowers, haybines and balers, expect problems with frequent plugging.
- **For grain:** harvest should occur when approximately 70% of the seed is ripe and when seed begins to shatter (22%–30% moisture content), which is approximately 100–120 days after seeding. Most older model combines will require some modification to prevent plant fibre from wrapping around shafts, chains, etc. This includes use of rubber belts to cover the chains in the feeder-house and covers over any shafts (Photo 7–1).

Photo 7–1. Use rubber belts to prevent plant fibre from wrapping around shafts, chains, etc. Courtesy of Manitoba government.

Dry stem stalk yields in Ontario have ranged from 6.4–19.8 t/ha (2.9–8.8 ton/acre) of dry, retted stalks per acre averaging 7.4 t/ha (3.3 ton/acre).

Retting and Turning

Retting is the process of beginning to separate the bast fibres from the hurds or other plant tissues. It is done in the field, taking advantage of the natural elements of dew, rain and sun, or under controlled conditions using water and/or chemicals. The method chosen depends on the end use of the fibre.

Successful field retting requires a delicate balance of nightly dews and good daytime drying conditions. Southern Ontario climate may dictate that field retting should be done no earlier than the end of July in order to ensure adequate dew conditions. The length of the retting process is critical for optimum fibre yield and quality. It typically takes 12–18 days to complete. The windrows are turned vigorously, once or twice, with a tedder or windrow inverter to facilitate uniform retting of the windrow and to knock the leaves off the stems. Excessive leaves will hinder drying and may cause the straw to contravene the *Controlled Drugs and Substances Act, 1996.*

Baling and Storing

For fibre-hemp, stalk moisture should be less than 15% at time of baling, and should continue to dry to about 10%. Baling can be done with any kind of baler. Large round, soft-core balers may be most satisfactory to allow bales to dry more quickly in storage. Bales must be stored indoors under dry conditions to stop the retting process before the fibres become rotted. Bales stored under plastic, based on experiments with hay storage, would indicate that moisture would be wicked up from the ground and some spoilage would take place. Bales placed on pallets will have less spoilage.

Dry grain hemp to 12% moisture for storage. Store in a cool, dry environment.

Insects and Diseases

More than 50 different viruses, bacteria, fungi and insect pests are known to affect hemp. However, hemp's rapid growth rate and vigorous nature allow it to overcome the attack of most diseases and pests.

As the concentration of the hemp crop and alternative disease hosts increase in a given area the number of, and population of organisms will tend to increase. A number of pests have been noted in hemp fields in Ontario including common moulds of hemp, *Botrytis cinerea* (gray mold) and *Sclerotinia sclerotiorum* (white mould). Sclerotinia also affects soybeans, edible beans, canola, buckwheat and sunflowers. The effect of these diseases on hemp (and hemp as an alternate host) may not be known until hemp is grown more intensively in bean and canola growing areas. Fusarium lesions have been noted on the roots of hemp plants. European corn borer has affected some stands in southern Ontario

A limited number of pesticides are registered for hemp in Ontario. Crop rotation would appear to be the best cultural practice to avoid disease build-up until more is known about hemp's susceptibility to disease organisms. A 4-year rotation is recommended. Hemp should not follow soybeans, dry edible beans, canola or sunflowers.

Wind and hail damage can be significant in the hemp crop. Tall plants with lots of high leaves can be bent over quite easily by mid-to late-summer storms. Broken plants will partially recover if not broken too low on the stalk.

For further production information go to ontario.ca/crops (search for *Specialty Cropportunities,* then go to Industrial and Miscellaneous Crops, then Fibre).

MISCANTHUS

Production Requirements

Soil Types: Miscanthus is suited to most soil types. Yields are lower on extremely heavy or light soils

Soil pH: 5.4–6.8

Recommended Rotational Crops: Miscanthus is a long-term perennial and crop rotations do not apply. Wheat or other cereals may act as a nurse crop during establishment

Minimum Soil Temperature: 4°C for planting rhizomes and 10˚C for planting plants or plugs

Optimum Air Temperature: 24°C–29°C

Earliest Planting Date: Early to late May

Required Growing Season: Perennial crop 10+ years

Miscanthus is a relatively new perennial crop for Ontario that has industrial and agricultural uses for fibre, biocomposites, paper, bioenergy (liquid and solid), livestock and poultry bedding and ginseng bedding.

Variety Selection

Miscanthus is a perennial C4 rhizomatous grass originating from Asia. Varieties range in their frost tolerance and winter hardiness, so proper variety selection for particular growing regions is important. Breeding for new varieties is limited. The Biomass Producers' Co-op website (www.ontariobiomass.com) lists varieties and other variety specific information.

As a result of its perennial nature, miscanthus tends to be more drought tolerant than annual crop types. The crop goes into a conservation mode during dry periods but is able to continue growth quickly when the drought period passes. Yield declines due to dry conditions tend to be much less than experienced with annual crops.

Planting

Miscanthus is established using rhizome transplants, rhizome plugs or seedling plugs and is generally spaced at 1 m (3 ft) between and within rows. The final stand should be approximately 12,000 plant/ha (4,850 plant/acre). Plant good quality rhizomes when sufficient soil moisture is available to ensure adequate stand establishment.

Greenhouse seeding or propagation can be started 4–8 weeks prior to field planting. Field transplanting is best from mid-April to May, after risk of frost has passed. Weed control is required during the establishment year as the newly emerging plants are slow growing and non-competitive following planting.

Techniques are being developed to harvest rhizomes out of the field, process them for size and plant them into new fields within days of harvest. Rhizomes must be protected from desiccation between root stalk harvest and replanting.

Fertility Management

Limited Ontario fertility guidelines exist. Research and recommendations from outside Ontario do not necessarily apply to Ontario growing conditions. Nitrogen requirements will depend on growing location, soil type and market conditions. Ontario research suggests that a range between 80–115 kg/ha N (70–100 lb/acre N) provides the best crop response. Excess nitrogen can cause crop lodging in some varieties, which will affect crop quality and ease of harvest. Nitrogen fertilizer should not be applied during the seeding year because it encourages weed competition. Table 7–4, *Range of nutrient removal rates of fall-harvested and over-wintered miscanthus varieties in Ontario (Engbers 2012) and compared to literature values* shows the range in nutrient removal from various harvest timings and methods.

The amount of phosphorus and potassium required will depend on the harvest method used. Miscanthus that is harvested in late fall or from spring-baled windrows will have lower requirement for phosphorous and potassium because these nutrients leach out of the biomass. Harvest in the summer or early fall will remove more of these nutrients with the harvested biomass. Phosphorus and potash fertility should be at target soil test levels (12–18 ppm P and 100–130 ppm K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting, at rates that meet crop removal rate plus an amount that will build up the soil test over time. See *Fertilizer Guidelines* in Chapter 9, *Soil Fertility and Nutrient Use.*

Harvest and Storage

Harvest

Miscanthus is commonly harvested in one cut each year and the harvest method will depend on the end use of the crop. Miscanthus is typically harvested in late winter, or left standing over winter and then harvested in early spring. Allowing the crop to stand over winter will improve stem dry down, leaf drop, and nutrient movement to the roots and soil by translocation and leaching. Spring-harvested miscanthus will have approximately 10% moisture content and will be of higher quality for combustion with less "clinkers." Fall harvest will yield up to 25%

Table 7–4. Range of nutrient removal rates of fall-harvested and over-wintered miscanthus varieties in Ontario (Engbers 2012) and compared to literature values

Legend: – = no data available

Nutrient	Harvest Timing	Nutrient removal rates[1]		Literature values[2]
		Elora	Ridgetown	
Nitrogen	fall	40–80 kg N/ha	20–25 kg N/ha	20–60 kg N/ha
	spring (over-wintered)	18–43 kg N/ha	20–25 kg N/ha	–
Phosphorus	fall	6 kg P/ha	4 kg P/ha	3–5 kg P/ha
	spring (over-wintered)	3 kg P/ha	3 kg P/ha	–
Potassium	fall	30–55 kg K/ha	13 kg K/ha	24–83 kg K/ha
	spring (over-wintered)	16 kg K/ha	7 kg K/ha	–

100 kg/ha = 90 lb/acre

Source: B. Deen, University of Guelph, 2015 (prepared by K Withers).

[1] Nutrient removal rates are presented as a range that encompasses the outcome of a trial consisting of four nitrogen fertilizer rates (0, 40, 80 and 160 kg N/ha).

[2] Kering, et al., 2011. Oklahoma; Propheter and Staggenborg, 2010. Kansas.

more, but is higher in moisture at cutting. Summer or early fall harvest (prior to natural senescence) could reduce winter hardiness and stand longevity. Standard field-crop equipment including sickle/disc mowers, haybines, round/large square balers and forage harvesters are able to handle this voluminous crop. Currently there are no established grades. Quality specifications are determined by the market.

Storage

Storage will depend on end use. Miscanthus has been stored in ag-bags; under cover in a building, as well as outside — with and without tarps. Miscanthus straw deteriorates less rapidly than cereal straw. Further processing may be required, such as chopping, pelleting and other treatments that will increase the density and improve storability of the crop.

Weed Control

Weed control options are limited, so select field sites with low weed pressure. A herbicide burn-down using a non-selective herbicide, such as glyphosate, in the previous fall can aid in reducing pressure from winter annuals and biennial weeds. The stale seedbed technique prior to planting is useful when there are few options to control weeds once a miscanthus crop has been planted and is emerged. The stale seedbed technique involves working the soil well before planting; where weeds are allowed to emerge for several weeks followed by the application of a non-selective herbicide, like glyphosate, to kill emerged weeds. Seeding or planting directly into the killed weeds, with minimal soil disturbance will allow the crop to establish before the next flush of weed emergence. In general, control of grassy weeds is more difficult because herbicides that are effective against grasses cause unacceptable injury to miscanthus. The extent of crop injury caused by herbicides depends on the propagule type (e.g., seed, plug/transplant, rhizome) and also on variety or genotype.

Insects and Diseases

In Ontario, there are no known insect or disease pests that cause economic losses to miscanthus at this time. Nematodes and rabbits have caused some issues. In other regions, European corn borer and western bean cutworm have been identified as insect pests. Few pest control products are registered on this crop.

For further production information, go to ontario.ca/crops.

QUINOA

Production Requirements

Soil Types: Sandy and loam soils. Soils prone to crusting may drastically reduce germination

Soil pH: 4.8–8.5

Recommended Rotational Crops: Corn, cereal crops

Minimum Soil Temperature: 5°C–10°C

Optimum Air Temperature: Prefers a temperate to semi-arid climate. Temperatures above 35°C may cause plant dormancy or pollen sterility

Earliest Planting Date: Plant early, similar to spring cereals

Required Growing Season: 90–120 days

Quinoa is typically used as a cooked whole grain, traditionally in South American cuisine, and is also less commonly used as a milled grain for flour.

Planting

Quinoa is an annual crop. It is generally direct-seeded at a depth of 1.5–2.5 cm (0.5–1 in.), in rows 38–76 cm (15–30 in.) wide. The target seeding rate is 325,000 seeds/ha (131,500 seeds/acre). Seed availability of commonly grown cultivars can be limited. Close attention to planting rate is required to account for large variations in seed size and percent germination.

Fertility Management

Limited Ontario fertility guidelines exist. Experience from other jurisdictions suggests a range of 100–120 kg/ha (90–105 lb/acre) of nitrogen is sufficient for plant growth and optimal yield. Phosphorus and potassium fertility should be at target soil test levels (12–18 ppm P and 100–130 ppm K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting, at rates that meet crop removal rate plus an amount that will build up the soil test over time. See *Fertilizer Guidelines* in Chapter 9, *Soil Fertility and Nutrient Use.*

Harvest and Storage

Harvest

Harvest occurs approximately 90–120 days after planting depending on the cultivar. Quinoa can be harvested using a combine with a standard header or sorghum header. The seed is disc shaped and is approximately 1.5–2 mm in diameter, so appropriate-sized screens/concaves are required. High humidity or frequent rain may cause mould or sprouting on seed heads. Quinoa can tolerate light frosts. Plants dry quickly resulting in potential grain loss. Yields in Ontario field trials range from 134–240 kg/ha (120–215 lb/acre).

Storage

Limited post-harvest storage research has been conducted on quinoa. Oil and protein contents of quinoa seed are similar to that of sunflower seed; therefore, sunflower storage conditions can serve as a general guide for quinoa.

Pest Management

There are limited or no pesticides registered for this crop in Ontario. For information on possible minor use registered products, a summary of all active, historical and registered minor use products is available from the **OMAFRA Minor Use Coordinator.**

Weeds

Quinoa is closely related to the common weed species lamb's-quarters. During vegetative stages the two species look very similar. Early season weed management is required. Weed control options are limited, so use field sites with low weed pressure. A herbicide burn-down in the previous fall, using a non-selective herbicide, such as glyphosate, can aid in reducing pressure from winter annuals and biennial weeds.

Insects and Diseases

Tarnished plant bug, stem borer (unknown species), flea beetles, aphids (including sugarbeet root aphid, *Pemphigus populivenae*), leafhoppers and beet armyworm are known pests of quinoa.

Stalk rot (*Phoma* spp.), fungal leaf spots, damping off, downy mildew (*Peronospora farinose*), leaf spot (*Ascochyta hyalospora*), gray mold (*Botrytis cinerea*), and bacterial blight (*Pseudomonas* spp.) are known diseases of quinoa.

To date, tarnished plant bug and phoma stalk rot have been the most significant pests in quinoa in Ontario. Large numbers of tarnished plant bugs have been observed feeding on quinoa in Ontario field trials; however, the impact of damage on yield is not known. Birds are also known to feed on quinoa.

Comments

For further production information, go to ontario.ca/crops and search for *Cropportunities*.

SUNFLOWER

Production Requirements

Soil Types: Sunflowers are suited to most soil types. Yields are lower on poorly drained or very light soils

Soil pH: 6.0–7.5

Recommended Rotational Crops: Corn, cereal crops

Should Not Rotate With: Soybeans, dry edible beans, canola, camelina and buckwheat

Minimum Soil Temperature: 6°C

Optimum Air Temperature: 25°C–28°C

Earliest Planting Date: Early May

Required Growing Season: 100–120 days

Sunflower is a tall, broad-leaved, usually single-stemmed plant, with one head per plant. Plants are heliotropic, which means that the heads follow the day's sun. They have a deep taproot, which allows them to access deep water and nutrient supplies that are generally unavailable for many other annual crops. As a result, sunflowers can handle dry soil conditions better than most crops.

Sunflowers have been grown in Ontario for several decades. The main markets for Ontario sunflowers have been for birdseed and confectionery uses. Both black seeded and striped sunflower seeds are sold into the birdseed markets. Currently there are no sunflower oilseed crushing markets in Ontario. Acreage in Ontario has ranged between 500–1,000 ha (1,250–2,500 acres) over the past decade.

Variety Selection

Sunflowers can be classified as either oil or confectionery. Oil-type sunflowers have black hulls and can be conventional hybrids, dwarf hybrids, mid-oleic or open pollinated varieties. Dwarf hybrids mature 6–13 days earlier than conventional hybrids. Open pollinated sunflower (Sunola) varieties are shorter stature 60–90 cm (2–3 ft), have high oil content and require less heat to mature than normal sunflowers, but they do not have good disease resistance.

Confectionery sunflowers have striped hulls and are grown for the human food market. Of the confection sunflowers, only the varieties producing the largest seed are used for human consumption, but these varieties are susceptible to bird and insect damage.

Hybrids have many advantages over open-pollinated varieties. Advantages include:

- approximately 20% greater yield
- better disease resistance (e.g., downy mildew, rust verticillium wilt)
- high degree of self-compatibility, which reduces the need for pollinators
- more uniform height and moisture content at harvest

Variety testing is conducted through the National Sunflower Association of Canada, with information available (www.canadasunflower.com).

Rotation

Sunflowers should not be planted in the same field more than once every 4–5 years, due to disease build-up. Canola, dry edible beans, soybeans, buckwheat and hemp are all hosts of white mould (*Sclerotinia*). Closely monitor rotations with these crops or avoid them altogether.

Volunteer sunflowers can also be a problem in some crop rotations. Sunflowers are susceptible to herbicide carryover from herbicides such as atrazine and sulphonylurea (ALS) herbicides.

Tillage and Seedbed Preparation

Sunflowers require a firm, moist and weed-free seedbed. Conventional tillage is usually preferred over no-till, mainly for weed control.

The best crop performance is on well-drained, medium-textured soils. Sunflowers can also grow well on sandy soils, but yield will be reduced under moisture stress during dry conditions. Poorly drained soils will delay planting, delay growth and increase disease pressure.

Planting

Sunflowers are planted in early May, similar to corn, and usually bloom in late July. They require approximately 100–120 days to mature. Seedlings are relatively tolerant to frost, up to the 4-leaf stage. A delay in planting beyond May 15 could increase the risk of frost damage prior to maturity in the fall. When delays in planting are unavoidable, use early-season hybrids/varieties.

Optimum planting depth is 3–5 cm (1.25–2 in.), and not more than 8 cm (3.25 in.), into moisture. Sunflowers are prone to lodging in heavier soils or where there is heavy rain and wind.

Ideal row width is 60–90 cm (24–36 in.). Use a corn planter with appropriate seed adjustments or a grain drill with some of the runs blocked-off. Row crop unit planters are preferred since grain drills typically result in poorer emergence. The recommended seeding rate is 40,000–60,000 plants/ha (16,000–24,000 plants/acre). Confection sunflowers should have a final stand target no greater than 45,000 plant/ha (18,000 plants/acre), to help encourage large seed size. Narrow row spacing, 18–25 cm (7–10 in.), increases the risk of white mould. Planting east/west can decrease lodging as sunflower heads face to the east and cause plants to bend in that direction.

Fertility Management

The recommended amount of nitrogen for sunflowers is 90 kg/ha (80 lb/acre). Nitrogen fertilizer use is most efficient when it is applied as a side-dress before the plants are 30 cm (12 in.) tall. Phosphorus and potassium fertility should be at target soil test levels (12–18 ppm P and 100–130 ppm K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting, at rates that meet crop removal rate plus an amount that will build up the soil test over time. See Tables 7–5, *Phosphate guidelines for sunflowers* and 7–6, *Potash guidelines for sunflowers*.

Where manure is applied, reduce the fertilizer application according to the amount and quality of manure, Chapter 9, Table 9–10, *Typical amounts of total and available nitrogen, phosphate and potash from various organic nutrient sources.*

Table 7–5. Phosphate (P_2O_5) guidelines for sunflowers

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	110 kg/ha (HR)
4–5 ppm	100 kg/ha (HR)
6–7 ppm	90 kg/ha (HR)
8–9 ppm	70 kg/ha (HR)
10–12 ppm	50 kg/ha (MR)
13–15 ppm	20 kg/ha (MR)
16–30 ppm	20 kg/ha (LR)
31–60 ppm	0 kg/ha (RR)
61 ppm +	0 kg/ha (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, phosphate applications may induce zinc deficiency on soils low in zinc and may increase the risk of water pollution.

Table 7–6. Potash (K_2O) guidelines for sunflowers

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	170 kg/ha (HR)
16–30 ppm	160 kg/ha (HR)
31–45 ppm	140 kg/ha (HR)
46–60 ppm	110 kg/ha (HR)
61–80 ppm	80 kg/ha (MR)
81–100 ppm	50 kg/ha (MR)
101–120 ppm	30 kg/ha (LR)
121–250 ppm	0 kg/ha (RR)
251 ppm +	0 kg/ha (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 application on soils low in magnesium may induce magnesium deficiency.

Harvest and Storage

Harvest

Typical sunflower yields in Ontario range from 1,500–2,000 kg/ha (1,300–1,800 lb/acre). Plants are ready for harvesting when the back of the heads turn yellow and bracts around the head are brown, hard and dry. Seeds at this stage have approximately 50% moisture. Harvest typically occurs between September and mid-October. Timely harvest that occurs when the crop reaches maturity will prevent bird damage and head rot.

Sunflowers are best harvested with a combine equipped with a western-style or modified row crop head. Some producers have had success with a small grain head, but grain loss is usually higher. Most combines are adapted with long seed-gathering pans extending in front of the cutter bar to collect and salvage shattered seed. The reel is typically removed or raised for sunflower harvest. To prevent seed damage, use the slowest cylinder speeds with the largest openings. Reduce air flow to prevent seeds from being blown through the back.

Drying of a late maturing crop will be facilitated by a killing frost; however, early frost may reduce yield and oil content. To avoid shatter loss and exposure to birds, harvest at a higher percentage moisture and dry seeds.

Storage

After harvest, clean seed to remove dockage. For proper storage, seed must contain 9.5% moisture or less. Dry seed at higher moisture content immediately after harvest. Sunflowers dry easily in conventional grain dryers. Confection types may wrinkle or be scorched. Use low-temperature drying to prevent heat damaged, scorched or burned sunflower seeds. Heat damaged seeds will have a distinct odour and appearance that is disliked by birds and consumers, and are therefore difficult to market. Higher drying temperature can also be a fire risk. Allow the crop to cool before storing. In general, bins will hold 70% as much tonnage as grain corn.

Caution

Dry sunflower seeds at a low temperature, because fine hairs and fibres from the seed coat could ignite when put through the drying fan.

Weed Control

Sunflower seedlings suffer from weed competition. Early season weed control is important for maximum crop performance. As sunflowers mature, they become better able to compete with weeds.

The crop can be harrowed before seedling emergence to remove emerging weeds before they become established. A light spring-tooth harrowing can remove late-emerging weeds when sunflower seedlings are between the 4- and 6-leaf stage. Harrowing is best done under hot, dry conditions to reduce crop damage. Inter-row cultivation is also recommended.

For herbicide options refer to OMAFRA Publication 75, *Guide to Weed Control.* Herbicide tolerant sunflower varieties allow for an effective chemical weed control. Refer to seed suppliers for more information.

Insects and Diseases

Insects are typically not a problem in sunflowers when first introduced in a region. After several years, pest populations will build. Scouting and control measures will have to adapt to maintain productivity.

Banded sunflower moth has been a major pest, feeding on sunflower florets and seeds. The moth is small, straw-colored, about 7 mm (0.3 in.) long with a brown triangular area in the middle portion of the front wings. Larvae emerge 1.5 mm (0.6 in.) long, light-coloured with a dark brown head and they darken to reddish-purple and finally green colour at maturity. Full grown larvae are about 10 mm (0.4 in.).

Seed will pass normally through the combine with damage from mild infestations; however, severe infestations can inhibit harvest due to uneven maturing of heads combined with secondary disease infection.

Harvested seed from infected fields can also be a source of banded sunflower moth. Keep the sunflowers cool and dry. If stored for long periods, the larva will hatch and consume stored grain. Any escaping moths are difficult to control and can contaminate grain storage bins, warehouses and retail areas.

Sclerotina or white mould is the most important disease in sunflower crops. Descriptions of insects, pests 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.*

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

For more detailed sunflower production information, see the *Sunflower Production Guide* of the National Sunflower Association of Canada at www.canadasunflower.com.

SWITCHGRASS

Production Requirements

Soil Types: Switchgrass is suited to most soil types. Yields are lower on extremely heavy or light soils

Soil pH: 6.0–6.8

Recommended Rotational Crops: Switchgrass is a long-term perennial crop and rotation crops do not apply. Cereal crops may serve as nurse crops during establishment

Minimum Soil Temperature: 10°C

Optimum Air Temperature: 24°C–29°C

Earliest Planting Date: Late April to May

Required Growing Season: Perennial crop 10+ years

Switchgrass is a relatively new perennial crop for Ontario that has industrial and agricultural uses for fibre, biocomposites, paper, bioenergy (liquid and solid), livestock and poultry bedding, and ginseng bedding. It is also know by other names such as tall panic grass, tall prairiegrass and thatchgrass.

Rotation

Switchgrass is a long-term perennial crop used for fibre, biocomposites, paper, bioenergy, animal feed and bedding. It has an extensive root system that gives the crop relatively good drought tolerance. Once established it is not rotated to other crops for many years. Switchgrass production is highest on fertile soils but is also well suited to marginal lands where other annual crops are less productive.

Tillage and Seedbed Preparation

Switchgrass seed is very small, and therefore requires a seedbed that ensures good seed to soil contact. Establishment has been most successful on well-drained, medium-textured soils that warm quickly and where weed competition is low. A light packing prior to planting will improve uniform seeding depth and again following seeding will improve the seed to soil contact.

Seeding switchgrass following soybeans in the rotation has provided a low-residue, firm seed-bed well adapted for no-till seeding.

Planting

Planting generally occurs mid-spring, but can also occur in the fall. The optimum seeding rate is 9 kg/ha (8 lb/acre) or less of pure live seed with a seed weight of 570,000 seeds/kg (260,000 seeds/lb). Switchgrass seed has strong dormancy. Pure live seed is a measure of the amount of live seed in a bulk seed lot. The seed is very small which requires a good seedbed to ensure good seed to soil contact. Seed is typically planted in 18 cm (7–7.5 in.) row widths at a depth of 1–1.5 cm (0.25–0.5 in.). Soil moisture is required for good emergence. Weed control is absolutely critical to establishment and production success, therefore, a nurse crop of spring wheat may promote better stand establishment, reduce weed pressure and provide income during the first year. Spring wheat is preferred over oats or barley as spring wheat tillers less, and causes less shading of the switchgrass seedlings. Seed spring wheat at full seeding rates. A nurse crop can aid in establishment success, but may limit chemical weed control options.

Fertility Management

Limited fertility guidelines exist for switchgrass. Current Ontario research indicates economical yield response to nitrogen rates of 50–80 kg/ha (45–70 lb/acre) depending on price of switchgrass and the expected yield potential. Nitrogen fertilizer should not be applied during the seeding year because it encourages weed competition.

In most cases, the only operation required following harvest is the application of nitrogen (N) fertilizer. For a spring harvest regime, 60–70 kg of N/ha (50–60 lb/acre) is sufficient to sustain production for an 8–10 t/ha yield target. A general rule of thumb is to apply 6 kg N/t (12 lb/ton) of biomass removed from the field.

Over-fertilization with nitrogen usually results in crop lodging, yield reductions and harvesting difficulties. Fertilization is commonly done in mid-to-late May, when the crop is about 15–25 cm (6 - 10 in.) high and when switchgrass has resumed its growth. This timing helps to minimize N losses where urea is used. Earlier N applications tend to help support grass weed growth, especially annual grass weeds and quackgrass. Switchgrass tends to have its peak N demand in year three. This is because considerable N is required to fully develop the large root system of the plant.

The amount of phosphorus and potassium required will depend on the harvest method used. Switchgrass harvested in late fall or from spring baled windrows will have lower requirement for phosphorous and potassium due to leaching of these nutrients out of the biomass and the loss of leaves that often hold a high amount of the nutrients. Harvest in the summer or early fall will remove more of these nutrients with the harvested biomass.

Most producers in Ontario mow the crop in late fall, allow it to winter in the fields in a swath and bale early the following spring. Producers in Ontario have found there is little decomposition of switchgrass over winter when using this system. The grass stays largely in a frozen state and rests on the 10 cm (4 in.) high stubble, keeping the swath separated from contact with the soil. By adopting a spring biomass harvesting regime, phosphorus and potassium fertilizers are usually not required on soils with medium-to-high fertility. Approximately 90%–95% of the potassium in switchgrass is leached back into the soil when the crop is left in the field over-winter. The annual potassium demand is very low when managed as an over-wintered crop since dry switchgrass contains only about 0.1% potassium. A 10 t/ha (4 ton/acre) switchgrass biomass crop will only remove 10 kg/ha (9 lbs/acre) of potassium from the field. Producers can soil sample for P and K periodically to monitor their levels.

Phosphorus and potassium fertility should be at target soil test levels (12–18 P and 100–130 K). If soil phosphorous and potassium levels are below target ranges, incorporate these nutrients into the soil ahead of planting, at rates that meet crop removal rate plus an amount that will build up the soil test over time. See *Fertilizer Guidelines,* Chapter 9, *Soil Fertility and Nutrient Use.*

Harvest and Storage

Harvest

Harvest management depends on intended end-use. Harvesting switchgrass twice in the same year, or before natural senescence has occurred, could lead to stand degradation. Switchgrass can be harvested in the summer if market conditions warrant, but this should not occur in the first year of growth, or on a yearly basis.

Standard field-crop equipment including sickle/disc mowers, haybines, and round or large square balers and forage harvesters can be used.

If switchgrass is being used for livestock bedding, pasture or roughage in the diet it can be grazed during the growing season or cut for hay in July or August with the possibility of two harvests. If used for cellulosic ethanol, switchgrass is often fall harvested since yield is highest, but moisture levels may be too high for long-term storage. If used as a biofuel for combustion, one-cut with windrowing in late fall and harvest in the spring provides the highest quality product for this market. Spring harvest will result in 15%–25% lower yields, but the grass will be of higher quality for combustion.

Switchgrass is usually left unharvested in the establishment year until the following spring to improve winter hardiness. Expected yield in the establishment year is about one-third of full stand potential and the year after establish is about two-thirds of full production potential. Once established and properly maintained, a switchgrass stand will remain productive for an indefinite period and can produce 8–12 t/ha of dry fall harvest material.

Storage

Market demands will determine what type of storage is required. Switchgrass has been tested for storage in Ag-bags or under cover as well as outside, with and without tarps. Results have been mixed but it is important to note that this crop stands up to the elements better than cereal straw.

The crop may need to be ground and densified or pelleted for ease of transport and/or end use. Research is ongoing to examine other methods of treatment (e.g., torrefaction) that will increase the density and storability of the crop.

Insects and Diseases

Specific pests observed on this crop in Ontario are based on limited experience. To date rust (*Puccinia* spp.), has been the most significant issue in Ontario. Other diseases and insect pests of switchgrass include: head smut (*Tilletia maclagani*), viruses (barley yellow dwarf virus, panicum mosaic virus), grasshoppers, leafhoppers, aphids, stem borers and wireworms.

Weed Control

Weed control prior to establishment and during the first 1–2 years is critical for achieving an adequate stand, since weeds will compete with establishing plants. There are no registered herbicides for switchgrass which makes weed identification, pre-plant herbicide and tillage options for control more important.

For further production information, refer to:

- Ontario Biomass Producers' Association at www.ontariobiomass.com
- Switchgrass Production in Ontario at www.reap-canada.com
- ontario.ca/crops

Other Biomass Crops

Other potential biomass crops in Ontario include perennial grasses (big bluestem, prairie cordgrass, indian grass) and annual grasses (pearl millet, sorghum, sudangrass). Refer to *Annual Forages* in Chapter 3, *Forages*.