CHAPTER 14

Alternative Crops

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For the Upper Midwest, alternative crops may be considered as any crop besides corn, soybean, small grains, or alfalfa. A renaissance of interest in cultivating alternative crops is occurring, primarily among small-scale and organic producers. Organic producers naturally have more diversified systems into which alternative crops can fit. In addition to the direct benefits to plant growth of rotations that utilize diverse crops, the incorporation of alternative crops may provide environmental benefits such as reduced pesticide use, enhanced soil and water quality, promotion of wildlife diversity, as well as economic benefits including the opportunity for producers to take advantage of new markets and premium prices, to spread economic risk and to strengthen local economies and communities.

TOM AND DEETTA BILEK

Figure 14-1. ***Grain sorghum (front) and grain amaranth (back).***

While the adoption of alternative crops can provide real advantages, it also carries real risks. Special requirements, variable yields and shifting markets can be expected. The smart grower will carefully research their market options before investing the time, effort and money required. Before adopting one or more alternative crops for full-scale production, there are several steps producers need to take (Table 14-1).

Selecting alternative crops

GOALS

There can be a number of reasons for growing an alternative crop (Table 14-2). While producers need to consider the economics involved with alternative crops, sometimes the primary factor in choosing to grow an alternative crop is not the direct economic value. Instead, the main consideration can be the benefit to the whole farming system like increased soil fertility, weed control, or other benefits of increased diversity. In addition, some producers who appreciate the value of local food production may grow crops with unique nutritional traits for local markets and consumption.

Table 14-1. Steps to take before choosing to grow an alternative crop

• Identify your goals
• Assess your resources
• Assess the crop growth and production requirements
• Get connected to others with experience
• Develop a marketing plan
• Seek start up funds
• Assess production costs, yields, and prices
• Begin with a small test plot

Table 14-2. Why grow alternative crops?

• Adding extra income
• Produce forage or feed for on-farm use
• Improve soil conditions
• Diversify operation
• Reduce disease or insect problems
• Enhance environmental sustainability

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Figure 14-2. *Tractor-driven cutter used to harvest dry beans.*

RESOURCE ASSESSMENT

Producers need to assess the fertility and drainage characteristics of their soil as well as climate conditions relative to an alternative crop before committing. Other considerations are available equipment and labor, special labor and equipment needs for planting, cultivating and harvesting, transporting, and marketing. Seed and some varieties may be difficult to find. Producers should also consider their financial resources before trying a new crop. For some crops, there will be an initial investment of purchasing or renting new equipment (Figure 14-2).

PRODUCTION REQUIREMENTS

Alternative crops may have unique temperature, nutrient and water requirements. Disease and insect pests may also be new (Figure 14-3). Producers need to examine what, if any, pest control options are available that are organic and whether the options are reliable and effective. It is also important to consider the timing of operations and amount of labor required fit into the current system.

SOURCES OF INFORMATION

Local growers, buyers and agricultural agencies are all starting places for more information. Networking with other producers who have experience is one of the best ways to learn about alternative crops. Other resources include joining organizations that focus on specialty crops, attending workshops and meetings for growers, and getting connected with the local extension office. Field days can also be a great source of information (Figure 14-4). A host of web resources for individual crops are usually available (see *For More Information* section at the end of this chapter).

MARKETING

Marketing is one of the trickiest aspects in beginning to grow a new crop. Producers may have the desire to grow an alternative crop, but they need to ensure that there is a market for it. Growers need a marketing plan before committing to an alternative crop; waiting until the crop is in the field is not the best time to figure out what to do with it! An element of added risk is that markets for these crops may not be consistent from year to year.

BRADY VICK

Figure 14-3. ***Sunflower plant infected with Sclerotinia head rot.***

Figure 14-4. ***Carmen Fernholz discusses flax at the Organic Field Day at the Southwest Research and Outreach Center in Lamberton, MN, in 2009.***

PRODUCER PROFILE

MARKETING

A producer from Wright County has these tips for what to know before deciding to grow an alternative crop:

- **What the market is**
- **The market requirements**
- **The distance to the market and costs of transport**
- **What type of equipment is required**
- **What kind of dry down the crop needs**

He says organic producers need to consider things over the long term like how the alternative crop fits into the rotation. He notes that location will often be a determining factor with alternative crops. In Minnesota, canning green peas will be easier to sell when producers are within 50 miles of Owatonna; otherwise it may be impossible. Another example is winter rye, which can be difficult to sell, but again this depends on location.

A producer from Waseca County points out that marketing is not always an issue when growing an alternative crop. If you are just feeding your own livestock, you have a built-in "market."

Producers will need to assess the demand and identify the crop varieties or qualities that are required by the buyer. This process will be aided if there is a local market and infrastructure for handling the alternative crop. If not, feasible methods of transport will be needed to get the crop to processors. The next step is to begin building relationships with buyers and understand market trends. It pays to have a backup plan if the crop does not meet buyer standards. One option may be to use the crop as feed when it does not meet food standards.

Some alternative crops may require direct marketing to consumers or selling to retailers rather than selling to wholesalers, but some are grown under contract. Determine the volumes for which contracts exist. For very small markets, one new grower can flood the market. It may be beneficial to have storage options to wait to sell alternative crops when market conditions improve.

START UP FUNDS

Producers should consider applying for a grant to assist with start up costs. Possible sources include state departments of agriculture or natural resources, Sustainable Agriculture Research and Education (SARE), the Farm Service Agency, and organic farming organizations.

ECONOMICS

Growers should analyze whether the alternative crop will be profitable in their farming system and under their soil and climatic conditions. Factors that need to be determined are production costs, expected yields and expected prices. As prices will vary significantly from year to year, producers should examine prices from several years to determine trends.

Purchasing crop insurance is one strategy for managing the economic risk in alternative crops. Consult with your local Farm Service Agency office about insurance options. Visit the Risk Management Agency website for more information—www.rma.usda.gov.

Table 14-3. Nutritional composition of various crops.
Adapted from the USDA-ARS, 2009.

CROP	PROTEIN	FAT	FIBER	CARBO-HYDRATES	CALCIUM	PHOS-PHORUS
	% OF TOTAL WEIGHT					
Dry field pea	22.8	1.2	25.5	60.4	0.06	0.37
Flax	18.3	42.2	27.3	28.9	0.26	0.64
Sunflower (kernels)	20.8	51.5	8.6	20.0	0.08	0.66
Buckwheat	13.3	3.4	10.0	71.5	0.02	0.35
Triticale	13.1	2.1	17.5	72.1	0.04	0.36
Proso millet	11.0	4.2	8.5	72.9	0.01	0.29
Grain sorghum	11.3	3.3	6.3	74.6	0.03	0.29
Grain amaranth	13.6	7.0	6.7	65.3	0.16	0.56
Pinto bean	11.3	1.2	15.5	62.6	0.11	0.41
Navy bean	22.3	1.5	24.4	60.8	0.15	0.41
Kidney bean	23.6	0.8	24.9	60.0	0.14	0.15
Soybean	36.5	19.9	9.3	30.2	0.28	0.70
Corn	9.4	4.7	7.3	74.3	0.01	0.21
Wheat, hard red spring	15.4	1.9	12.2	68.0	0.03	0.33
Oats	16.9	6.9	10.6	66.3	0.05	0.52
Barley, hulled	12.5	2.3	17.3	73.5	0.03	0.26

JIM RIDDLE

Figure 14-5. *Field Peas.*

PREPARING FOR ALTERNATIVE CROPS

Producers should test multiple varieties with test plots, preferably at more than one location. Cooperating with neighbors with similar interests in alternative crops will enhance the impact of this experimentation. Preparation for planting can begin before seeds go in the ground. Soil fertility can be enhanced using green manure crops, which can help control perennial and other difficult weeds. A firm seed bed is recommended for small-seeded crops. Fall tillage will create these conditions. Growers should locate a source of organic seeds if possible.

Reducing risk: Selecting alternative crops.

Learn as much as possible about new alternative crops you are considering. Connect with others who have experience with the alternative crop you choose. Test new crops on small-scale plots first. Unless you are growing the crop as feed for your own animals, do not grow a new alternative crop without a contract.

Alternative crop profiles

Alternative crops can be categorized by their use for feed, forage, fiber, fuel, or oil. Nutritional values of alternative grains are shown in Table 14-3. This chapter will summarize production for some of the more commonly grown alternative crops with proven adaptation to the Upper Midwest.

DRY FIELD PEA

Overview and use

Field peas have been grown successfully throughout the North Central region and Canada. Peas are grown for human consumption, animal feed, as well as a soil building crop. The grain contains 18 to 25 percent protein. Dried peas or pea flour are used for human consumption. Cream-colored varieties are grown in the North Central region for animal feed or forage. Because of their high protein concentration, dry field peas or pea flour can be used to fortify grain-based animal feed. Field peas can be substituted for soybean in hog rations. Peas lack the enzyme inhibitors found in soybean and do not require roasting or processing before feeding.

Pea forage is high in protein and low in fiber and can be used for pasture, hay or silage. It can be grown in a mixture of oat, barley, or triticale and used as a protein fortified forage. A mixture of two-thirds field pea and one-third oat is frequently used as a companion crop for alfalfa or clover. Peas leave minimal amounts of organic residue that breaks down quickly. When field pea is used as a green manure, the nitrogen contribution can be 25 to 50 pounds per acre.

Table 14-4. Field pea variety trial yields and traits.
Variety trials were conducted from 1997-1999 in Red Lake Falls, Fosston, Oklee, Kennedy, and Baudette, MN. Adapted from Kandel, 2007.

VARIETY	YIELD (BU/AC)	LEAF TYPE	MATURITY RATING	VINE LENGTH	SEED COLOR
Spitfire	63	Reduced leaves	Medium	Medium	Yellow
Carneval	58	Semi-leafless	Early	Medium	Yellow
Carrera	56	Semi-leafless	Early	Short	Yellow
Grande	56	Normal	Medium	Medium	Yellow
Highlight	55	Semi-leafless	Early	Short	Yellow
Majoret	52	Semi-leafless	Medium	Short	Green
Mustang	52	Semi-leafless	Very early	Short	Yellow
Profi	50	Semi-leafless	Early	Medium	Yellow

Types

Peas are characterized by seed color (yellow and green for human consumption; cream, brown or grey for animal feed) or growth habit. There are two main types of growth, climbing types that produce vines three to six feet long and dwarf or semi-leafless types that produce shorter vines two to four feet long. The leaflets of dwarf types are reduced to tendrils. They are widely grown in industry. Semi-leafless types lodge less and can be harvested more easily, but they tend to be less competitive with weeds.

Determinate and indeterminate types of field peas are found. Both types begin flowering 40 to 50 days after planting. Determinate varieties mature in 80 to 90 days. Indeterminate varieties flower over a longer period of time than determinate varieties and mature in 90 to 100 days, similar to wheat. In Minnesota, determinate varieties are generally used (Table 14-4). Indeterminate varieties may have immature green seed when harvesting.

Preferred conditions

Field pea is a cool season annual crop. Optimum temperatures for growth are between 55 and 65º F. They can withstand considerable frost exposure. If damaged by frost, they are able to re-sprout from nodes below the soil surface. The amount of moisture required for growth is similar to that of cereal grains. Early rains are best, followed by dry conditions during pod fill and ripening. Field peas are adapted to many soil types including sandy and clay soils, but they do not tolerate saturated or saline soils. The ideal pH is 5.5 to 6.5.

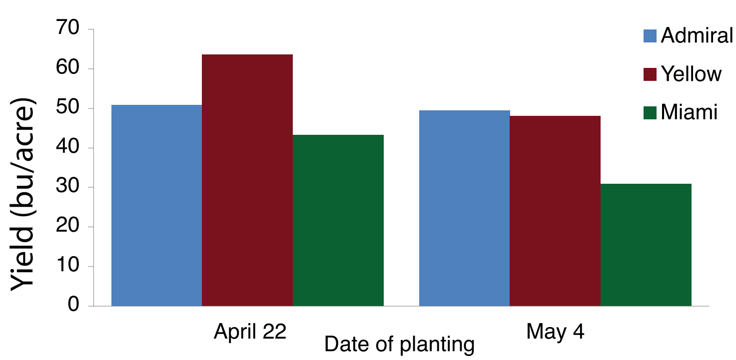

Figure 14-6. *Field pea yields at different planting dates. Three varieties of field pea were planted on April 22 and May 4 in Lamberton, MN in 2009. Earlier planting dates usually lead to greater yields.*

One producer from Lac qui Parle County says 'Mozart' is a good pea variety. Another variety he has had recent success with is 'Commander', which is from South Dakota. A different producer from Pipestone County has good results from 'DS Admiral'. All are yellow, semi-leafless varieties.

Planting date

Plant as soon as the soil can be worked in the spring. In the North Central region, pea is planted in mid-March to mid-April, as soon as soil temperature in the upper inch reaches 40 to 50 º F. It blooms in about 60 days and matures in 95 to100 days, similar to wheat. High tempera-

Field peas can be under-seeded with red clover, which is what one producer from Lac qui Parle County does. The field peas are harvested in late July. The red clover is cut back with a flail chopper, followed by chisel plowing. Some red clover remains to offer protection to the soil over winter.

tures slow growth and reduce seed set. Yields may decrease significantly when planting is delayed beyond mid-May (Figure 14-6). Fall plowing may aid in earlier spring planting.

Planting depth and rate

Pea is planted with a grain drill one to two and a half inches deep in six to twelve inch wide rows. Careful monitoring of grain drill seeding is required to avoid cracking seeds. Cracked seeds will not germinate. Rate of seeding is from 115 to 175 pounds per acre, depending on variety. A stand count of eight to nine plants per square foot is recommended as "competition" from weeds can become severe at lower plant densities. Seed should be sown into a firm seed bed that is relatively free of residues that can harbor pathogens.

Nutrient requirements

Peas are grown on a wide range of soil types. As a legume, pea uses bacterially fixed atmospheric nitrogen. Pea derives about 80 percent of its nitrogen through this symbiotic relationship. Inoculation of seed with the bacteria, *Rhizobium leguminosarium* will increase nodulation. Peas require phosphorous and potassium in relatively large amounts. Sulfur may be needed to enhance nitrogen fixation. Manganese may also be required.

Pest control

Peas are poor competitors with weeds. Both emergence and canopy development are slow.

PRODUCER PROFILE

Field pea experiences

A producer from Pipestone County has found that organic field peas are more popular now; they are used in organic feed for calf starter, pet food, and conventional hog feed. Field peas require much less processing for feed than soybeans, but they do not provide as large of a nitrogen credit as soybeans and it can be difficult to find organic seed. He likes to plant field peas at the end of March at two bushels/acre. He also has tried frost seeding them. One year he planted as late as April 29th (Figure 14-7). He was not happy with this stand because it was not as thick as he would like. He averages yields of 30-40 bushels/acre (field peas have 60 pounds to the bushel).

Figure 14-7. *Field peas prior to harvest in Pipestone County. A later than normal planting date led to increased weeds.*

One producer from McLeod County cannot plant field peas because fungal diseases are such a problem.

Weeds must be controlled prior to planting. Blind harrowing may be done, but pre-emergent cultivation can result in crop damage. If post-emergent weed control is performed it should be cultivation with a harrow at the four- to six-leaf seedling stage to lessen damage. Cultivation should be avoided once seedlings start branching but if it is necessary, a rotary hoe rather than harrow, should be used.

Field pea can be affected by severeal diseases. It is only moderately susceptible to Sclerotinia; normal-leaf, climbing types of pea are more susceptible than semi-leafless pea. A four-year rotation is generally recommended for Sclerotinia-susceptible crops including pulses. Crop rotation and early planting help to reduce the occurrence of powdery mildew *(Erysiphe polygoni)*.

Pea aphids may be a problem and can infect plants with viruses.

PRODUCER PROFILE

Field pea + barley

Another option is to grow field peas in mixture with a small grain of similar maturity. One producer from Faribault County grows these crops together. The mix is sold to an organic dairy for feed. He recommends an early-maturing barley variety so the two crops will mature together. He plants at a rate of 70 pounds peas and 50 pounds barley to generate a 1:4 ratio of peas to barley (20 percent peas and 80 percent barley). He warns that individual species' yields can vary greatly so exact ratios are hard to predict.


JIM STORDAHL

Figure 14-8. *Barley and peas just prior to combining.*

Harvesting

Timing of harvest is very important for field peas. Harvest usually occurs in late July or August. Harvesting pea is complicated by the prostrate growth habit and tendency of dry pods to shatter. Shattering can be reduced by harvesting before pods are completely dried or during times when atmospheric moisture is high such as early morning or at night. Field pea can be swathed or straight combined. Either way, the cutting platform should be set close to the ground. Careful combining is critical to avoiding seed damage. If there is severe weed pressure, consider swathing the peas before they are dry. Then allow the swaths to dry along with the weeds. The greatly improves harvesting and leaves cleaner peas in the hopper.

Field pea is harvested at 16 to 18 percent moisture. Swath yellow varieties when most of the seeds have turned yellow. Green peas are harvested at a slightly higher moisture content to maintain seed color. Green peas are susceptible to bleaching when pods are in contact with moist soil. Bleaching reduces seed quality. Field peas should be stored at 14 percent moisture.

A producer from Lac qui Parle County who grows field pea finds that in many cases the field pea yield will be made before lambsquarters or kochia really flush. Although these weeds create a harvest challenge, they will not impact the yield as severely as one might think.

Reducing risk: field pea. **Do not plant field peas into flax stubble. The stubble is long-lasting and will interfere with swathing. Seedbeds with little residue are best. To avoid disease, do not plant peas within four years of oilseeds and legumes. Avoid planting field peas in fields with cool season, early-emerging weeds like lambsquarters, kochia, wild mustard, and wild oats. Also avoid fields with buckwheat, nightshade, and Russian thistle, which will interfere with harvest. They will be too competitive with field peas and nightshade berries can stain field pea seed. To reduce risk, choose varieties with shorter vines or semi-leafless types that are more harvestable. Low planting rates can lead to weed issues because field pea is uncompetitive. Planting after mid-May is not recommended.**

DAVID L. HANSEN

Figure 14-9. *Flax.*

FLAX

Overview and use

Two main types of flax are grown: brown-seeded varieties for oil or feed and golden-seeded varieties for human consumption. Flax is grown primarily for the oil content of its seeds. Flax seed contains about 40 percent oil that is high in omega-3 fatty acid. Human consumption of flax seed has increased significantly in recent years as a result of research illuminating the health benefits of flax oil. Flax seed is also used in bakery products and as feed for chickens. The eggs are marketed for their high omega-3 fatty acid content and are sold for a premium price. Flax meal contains about 35 percent protein and is fed to livestock. Another traditional product of flax is fiber or linen cloth. In some areas, there may be a small niche market for flax fiber, but generally flax has been replaced by synthetic fibers. Flax is not used as a forage crop due to its high cellulose and lignin content.

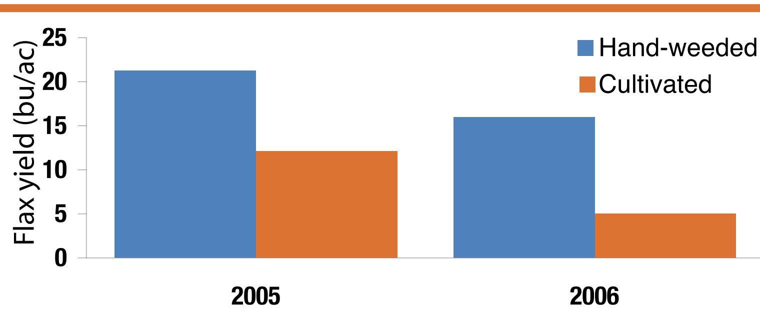

Figure 14-10. *Drought effects on organic flax yield. 'Norlin' flax was planted in 2005 and 2006 on an organic farm in Fertile, MN. The 2006 season was extremely dry and weeds became dominant. Subsequently, yields were lower than they were in 2005, particularly with typical weed control. Adapted from Kandel and Porter, 2006 and 2007.*

Table 14-5. Planting date effects on organic flax grown in Grygla, MN, in 2005. *Yields were significantly better and weed biomass was less at the earlier planting date. Adapted from Kandel and Porter, 2006.*

DATE OF PLANTING	YIELD (BU/ACRE)	WEEDS (% OF TOTAL BIOMASS)
May 12	18	38
May 13	9	53

Flax is a good crop in rotation with small grains. Three years between flax crops is recommended. It should not be grown on fields following brassicas, sugar beets or potatoes. It is often followed by clover or barley. It is a good companion crop for clover or alfalfa, as it is not competitive.

Preferred conditions

Flax is a cool-season annual that is planted in the spring in North Central states. It does well on soils that produce a good wheat or barley crop. Flax is adapted to well-drained loam to clay loam soil and does poorly on soil prone to erosion or high in soluble salts. It is not tolerant of overly wet or poorly-drained conditions. Droughty conditions that interfere with flowering and pollination will lead to dramatic reductions in grain yields (Figure 14-10). Flax grows best at a pH of 6 to 6.5.

Planting date

Early seeding is best. Planting from late April to late May is recommended for best yield, oil content, and straw. In Minnesota and North Dakota, flax is planted about the same time as oats. It will tolerate light frosts. When planting is delayed, yields are reduced (Table 14-5). Flax generally takes 90 to 110 days to mature.

Planting depth and rate

Plant at a depth of one-half to one inch into well-worked soil with little residue. A roller can be used to create a firm seed bed and will help achieve a uniform planting depth. Seed that is planted too deeply will delay emergence and result in weakened seedlings. The seeding rate for organic flax is 40 to 70 pounds per acre. Some organic producers plant at the higher ranges to promote flax competition with weeds. However, unless high levels of weeds are anticipated, higher planting rates may not be necessary (Figure 14-11). Yellow-seeded varieties tend to have lower seedling vigor and should be seeded at a higher rate.

Nutrient requirements

Flax is a light to moderate feeder with nutrient requirements generally close to small grains. In some parts of the Midwest, zinc deficiency in flax has been observed. Phosphorus levels are not

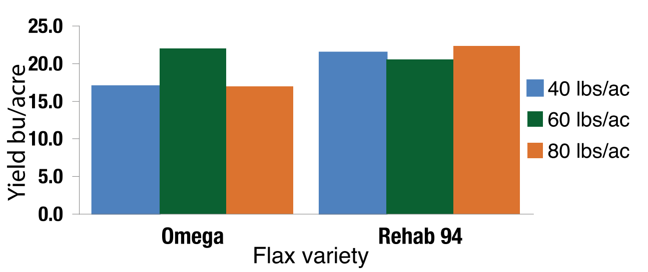

Figure 14-11. *Organic flax seeding rates and yield. Two varieties of flax, Omega (yellow type) and Rehab 94 (brown type) were planted at three different seeding rates in Rosemount, MN in 2007. The higher planting rates did not consistently increase yield.*

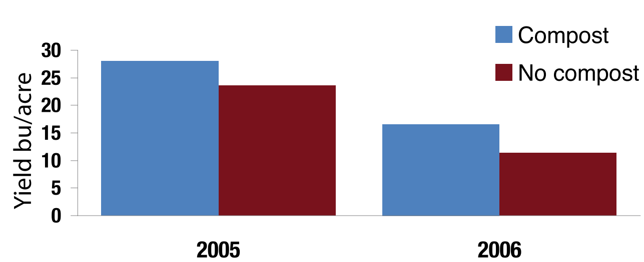

Figure 14-12. *Compost effects on organic flax in Iowa in 2005 and 2006. Compost was applied at four tons/acre in early spring. Yields were greater with compost application. Adapted from Delate et al 2005 & 2006.*

usually a problem. Planting flax after corn is not recommended for organic systems because of the nutrient depletion due to corn. Flax may have increased yields when following legumes in rotation or after compost application (Figure 14-12).

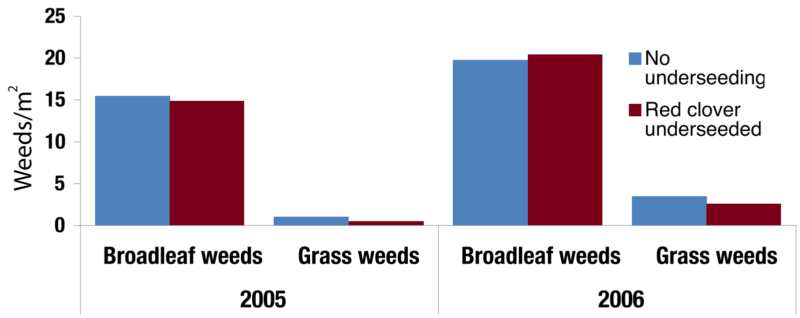

Figure 14-13. *Underseeded red clover effects on weeds in organic flax in Iowa in 2005 and 2006. Red clover did not significantly reduce weeds while flax was growing. However, the red clover had no negative effects on flax yield and it provided weed suppression and contributed nitrogen after the flax was harvested. Adapted from Delate et al, 2005 & 2006.*

Table 14-6. Organic flax underseeded with legumes.
Flax varieties were planted in Fertile, MN in 2005. In this trial, Carter performed significantly better than many of the other varieties. Adapted from Kandel and Porter, 2006.

VARIETY	COLOR	UNDERSEEDING	%WEED BIOMASS	YIELD (BU/AC)
Norlin	Brown	Red clover	45	13.3
		White clover	48	12.5
		None	51	12.1
Carter	Yellow	Red clover	41	14.4
York	Brown	Red clover	51	11.4
Bethune	Brown	Red clover	49	11.1
Hanley	Brown	Red clover	58	11.1

Pest control

Small-leaved flax seedlings do not compete well with weeds. Weed control prior to planting is essential. Grow flax in weed-free fields if possible; avoid fields infested with quackgrass. Fall tillage can help suppress perennial weeds. When possible in the spring, cultivate twice before planting to control early season weeds. Underseeding with red clover or other forages is a common approach to weed control (Figure 14-13 and Table 14-6).

Planting in two directions or cross-planting is another method for weed management. With this technique, seed is planted at a half rate in one direction, followed by a second pass at a half rate in another direction across the first seeding. The goal is for the flax to shade the ground more quickly to be more competitive with weeds.

Disease is generally not a problem in flax as disease resistant varieties are available. Insects also tend not to be problematic.

Harvesting

Flax is ready to harvest when stems turn yellow and bolls are brown. Seed should be at less than 12 percent moisture before combining. Flax with green stems requires a sharp cutter bar. Green weeds and uneven ripening of the crop can further complicate harvest. Because of this, flax is usually windrowed prior to combining until the seed has reached 8 to 10 percent moisture. A tall stubble (higher than for small grains) is recommended to facilitate pickup. Careful monitoring of combine settings is necessary to reduce seed damage.

Reducing risk: flax. Plant at adequate rates; low planting rates can lead to weed issues because flax is not competitive. Rotations should be three years long or longer. Maintain good weed control prior to planting flax.

PEA-FLAX MULCH EXPERIMENT

Field pea and flax are both crops that are uncompetitive with weeds. A study was conducted in Lamberton and Rosemount, MN, to determine if weeds could be controlled in these crops by using winter-killed cover crops. Spring oats, field pea, oilseed radish, berseem clover, and crimson clover were planted in the fall (Figure 14-14). In the spring, either field pea or flax were no-till planted into the mulch (Figures 14-15 and 14-16). Yields were greatly reduced by the mulch treatments and by the warm and droughty conditions. (Tables 14-7 and 14-8). The mulch effects on weeds were inconsistent.

Figure 14-14. *Berseem clover planted in the fall.*

Figure 14-15. *Field pea planted into winter-killed mulch in spring.*

Figure 14-16. *Flax planted into winter-killed mulch in spring.*

Table 14-7.
Field pea harvest following fall cover crops in 2007

	ROSEMOUNT		LAMBERTON	
Fall cover crop	Yield bu/ac	% Weed Cover	Yield bu/ac	% Weed Cover
Spring oat	7.2	16	5.5	18
Field pea	5.2	22	4.1	20
Oilseed radish	8.6	5	4.1	6
Berseem clover	4.5	11	3.5	29
Control	4.5	25	4.9	28

Table 14-8.
Flax harvest following fall cover crops in 2007

	ROSEMOUNT		LAMBERTON	
Fall cover crop	Yield bu/ac	% Weed Cover	Yield bu/ac	% Weed Cover
Spring oat	0.1	5	1.8	24
Field pea	0	35	1.0	32
Oilseed radish	0.1	4	0.8	38
Berseem clover	0.1	22	0.5	39
Control	0	29	0.3	40

SUNFLOWER

Overview and use

Sunflower is grown primarily for oil or seed. Two types of sunflower are grown: oilseed types and confectionary sunflower types used for baking, snacks, and bird food. Oilseed sunflowers are black-seeded and are either linoleic or oleic types. Confectionary sunflower varieties have a thick, striped hull and seeds are larger than those of oilseed varieties (Figure 14-18). Sunflower meal can be substituted for soybean meal in livestock feed.

Types/varieties

Most sunflower varieties are hybrids. They exhibit increased yield, uniformity, pest resistance, stalk quality, seed quality and self compatibility. Producers should select varieties with a maturity rating appropriate to the growing season for your area. Semi-dwarf sunflowers are available and are 25 to 35 percent shorter than other varieties. Reduced seed and oil yield in semidwarf varieties has been found during years with drought stress.

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Figure 14-17. *Sunflowers.*

Preferred conditions

Sunflower prefers well-drained soils with good water-holding capacity and neutral pH. Yields can be reasonably good on a range of soils including soils with low moisture, high salinity or poor drainage. In dry years, sunflower can yield somewhat well because it is deep-rooted and thus able to extract water from a greater volume of soil. The critical period for sunflower to receive moisture is 20 days before and after flowering. It uses less water than corn or soybean, but more than small grains. Good yields have been obtained on soils with pH ranging from 5.7 to over 8.

STRAND MEMORIAL HERBARIUM

Figure 14-18. *Confectionary (left) and oilseed (right) types of sunflower.*

Planting date

Sunflower will germinate at 39° F but a soil temperature of 50° F at a four-inch depth is required for uniform germination. Planting too early, when soil temp is below 50° F, will delay germination and increase susceptibility to seedling diseases. Sunflower will take longer to emerge compared to grains. In Minnesota and Wisconsin, planting occurs from early to mid-May. It produces best in temperatures from 65 to 90° F.

Planting depth and rate

Plant seed one-half to two inches, but not more than three inches, deep. Semidwarf varieties should not be planted more than two inches deep. Plant density varies by variety from 12,000 to 25,000 plants/acre (Table 14-9). Similar to soybean, sunflower compensates over a range of populations and yield does not increase above than 29,000 plants/acre. Oilseed

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Figure 14-19. *Verticillium wilt in sunflower.*

hybrids are planted at 15,000 to 25,000 plants/acre, depending on soil type, precipitation, and yield goals. Confectionary varieties are planted at lower populations, between 14,000 to 20,000 plants per acre, to produce large seeds.

Nutrient requirements

Sunflower is a medium to high feeder but requires less nutrients than corn. Nitrogen tends to be most limiting. 20 to 100 pounds of nitrogen generally will meet needs, depending on previous crop. Sunflower responds well to organic sources of nitrogen and seems to respond better to additional P than K.

Pest control

Sunflower is a good competitor with weeds after it has become established. The critical period for weed control is during the first four weeks after emergence. In the North Central states, wild mustard, wild oats and kochia are particular problems. Preplant, preemergence and postemergence tillage are all important for effective weed control. Weeds that emerge before the crop can be controlled with preemergence tillage using a spike tooth harrow, a coil spring harrow, or a rotary hoe up to one week after planting. Sunflowers can be harrowed or rotary hoed post emergence at the four to six leaf stage with an attrition rate of five to seven percent per operation. Sunflowers can be cultivated once or twice between the rows until the plants are six inches high.

Sclerotinia stalk, head rot (white mold), and Verticillium wilt can be problems (Figure 14-19). Choose resistant varieties when available. Rotations should be at least four years between sunflower crops. Non-susceptible crops include small grains, sorghum, and corn.

Rotations will also help to reduce, but will not eliminate, insect problems. Adjacent fields should not be planted with sunflower in subsequent years due to insect pests that overwinter in the soil.

Birds are also a pest of sunflowers (Figure 14-20). However, control options are limited as birds are adaptable to deterrents.

Table 14-9. Recommendations for sunflower plant populations for different parts of Minnesota.
Adapted from Robinson et al., 1982.

TYPE	LOCATION/SOIL	PLANTS PER ACRE
Oilseed	North	20,000
Oilseed	Central	20,000
Oilseed	Southwest	15,000
Oilseed	Southeast	20,000 - 25,000
Oilseed	Sandy soils	15,000
Oilseed	Irrigated soils	20,000 - 25,000
Confectionary	Droughty soils	15,000 - 20,000
Confectionary	Non-droughty soils	10,000

Harvesting

Seeds are physiologically mature when the back of the sunflower head turns yellow. Harvesting occurs after this point because the fleshy head requires additional drying time. Harvest at 18 to 20 percent moisture. Harvesting at lower moistures may lead to yield loss. Grain combines will need a

HOWARD F. SCHWARTZ, COLORADO STATE UNIVERSITY

Figure 14-20. *Bird damage on sunflower.*

sunflower head attachment and a pan for collecting shattered seed. Store between nine and twelve percent moisture for long-term storage.

Reducing risk: sunflower. **Select varieties that mature within the growing season, provide seed quality for the desired market and have resistance to common diseases and insect pests. Rotation is essential to avoid disease problems. Rotation will also reduce the buildup of weed species that are problematic in sunflower, in particular, mustard. Although modern sunflower hybrids have increased self compatibility, seed yield can be increased with pollination from honeybee colonies.**

Figure 14-21. *Buckwheat.*

BUCKWHEAT

Overview and use

Buckwheat is a fast-growing annual that is used as a grain crop, green manure, and smother crop. Its flowers provide a source of nectar for the production of buckwheat honey. Buckwheat grain is milled and the flour and groats are used for human consumption. It can also be combined with corn, oats or barley and used as a feed for livestock. Because the grain is high in the amino acid lysine, it provides a more complete protein than cereal grains.

Buckwheat makes an excellent green manure crop. It produces relatively large amounts of biomass in six to eight weeks. It has a dense root system in the top ten inches of soil and tap roots that can reach a depth of three feet. It is able to absorb relatively insoluble mineral nutrients by increasing the acidity of the soil in the root zone. When it is plowed under, the tissues decay rapidly and release nitrogen and other nutrients making them available to the following crop.

A producer from Redwood County uses buckwheat as a grain crop plus as a smother crop for Canada thistle. He wishes the market were stronger for the grain so he could utilize it more often.

Because of its rapid growth, buckwheat is also used as a smother crop to control weeds. It emerges in two to five days, establishes rapidly, and has a dense canopy. It may suppress quackgrass, Canada thistle, sowthistle, and others. It has been found to have allelopathic effects on barnyardgrass and common purslane.

While buckwheat is not a part of many breeding programs, there are several varieties available of buckwheat (Table 14-10).

THE BUCKWHEAT GROWERS ASSOCIATION OF MINNESOTA

Organic and sustainable producers in Central and Northern Minnesota formed a co-op to promote buckwheat production. They started out by developing facilities to clean buckwheat. They have since expanded their focus to include other alternative crops. Their services and products now include feed for livestock, seed and supplies, grain cleaning, corn drying, and grain storage. For more information, visit their website at http://www.buckwheatgrowers.com/index.htm.

STRAND MEMORIAL HERBARIUM.

Figure 14-22. ***Buckwheat has flowers, immature seed (green) and mature seed (brown) all at the same time.***

Preferred conditions

Buckwheat prefers cool and moist growing conditions. It does well on a wide range of soil types. It tolerates infertile soil, acidic soil and does well on soil with a high residue. It does not grow well on heavy soil, poorly drained soil or soil with high levels of limestone. It is susceptible to drying winds and drought. Excessive nitrogen, heavy rainfall and wind can cause buckwheat to lodge. Buckwheat is very susceptible to frost (below 32º F).

Planting date

Buckwheat germinates over a wide range of temperatures (45 to 105° F). Yields are best when planted in early spring after all danger of frost is past. One of the advantages of buckwheat is that the planting date is flexible as long as frost and high temperatures during flowering can be avoided. Buckwheat requires 10 to 12 weeks after planting to reach maturity, so it can be planted in the spring or in mid-summer. Spring seeding from May 25th to June 10th is recommended in North Dakota and Minnesota. Planting late can result in reduced yield if high temperatures occur during flowering. When planted in mid-summer (July), buckwheat is typically harvested after frost.

Planting depth and rate

Seed can be planted with a grain drill or broadcast. Seed is planted at a depth of one to two inches. A seeding rate of 40 to 55 pounds per acre is recommended, depending on variety. Large-seeded varieties are planted at the higher rate. Planting at overly high rates can lead to poor stands that lodge and produce lower yields. Cross-planting with a grain drill results in better spacing and reduced lodging. Preplant cultivation and good seed bed preparation help to ensure rapid emergence and establishment. A firm seedbed

Table 14-10. Variety trials of buckwheat conducted at several sites in North Dakota in 2004 – 2007.
Adapted from Berglund, 2007.

VARIETY	LODGING *	YIELD (LB/ACRE)
Mancan	5.6	1253
Koma	5.0	1312
Manor	4.7	1344
Koto	3.5	1325

* on a score of 0 to 9, with 0 = complete lodging and 9 = no lodging

is best for planting buckwheat. If broadcast seeding, drag field to incorporate.

Nutrient requirements

Buckwheat has moderate fertility requirements. In fertile soils or after alfalfa, no additional nutrients will be required. In fact, buckwheat is not recommended for very rich soils, as it will lodge. Buckwheat will produce higher yields on less fertile soils with the addition of the equivalent of 15 pounds N per acre.

Pest control

Weeds should be controlled with tillage prior to planting. Weeds are typically not a problem after the crop has become established but volunteer canola, mustard and sunflower can readily establish and be difficult to control in buckwheat.

Disease and insect pests do not present serious problems for buckwheat production.

A Redwood County producer says harvesting buckwheat is slow. It can take three weeks to dry down.

Harvesting

Because buckwheat is an indeterminate plant, flowers, green seed and mature seed are present on the same plant at the same time (Figure 14-22). Harvest occurs about 10 weeks after planting. At this point, 70 to 75 percent of the seeds will be mature but still retained on the plant. With delays, mature seed will drop. Swathing is necessary to hasten drying if the crop hasn't been killed by a frost. It should be cut in early morning to lessen shattering and left to dry. Buckwheat that was planted in mid-summer can be harvested after a light frost and then direct combined. A moisture content of less than 16 percent is required for safe storage.

When grown as a green manure crop, it is incorporated before seed sets, about four to seven weeks after planting. After being disked, it is left to dry for a few days and then tilled under.

A producer from Cottonwood County does not find volunteer buckwheat to be a problem. Flaming in the spring controls the volunteers well for him.

Reducing risk: buckwheat. **Avoid planting buckwheat following wheat, oats, barley or flax. Seed of volunteer plants of these crops will cause problems when cleaning the buckwheat crop. Removal of soil nutrients by a buckwheat crop can depress yield of the following crop. Care is needed to ensure that soil nutrient levels, especially phosphorus, are adequate for the following crop. Plant after the average date of frost in your region. Avoid planting late as high temperature and dry conditions during flowering can reduce yields. Control buckwheat used as a green manure early before most of seed matures, especially if the succeeding crop is not competitive with volunteer buckwheat. To reduce chances of volunteer plants in the subsequent year, the field should be tilled to incorporate residue and then tilled a second time one to two weeks later.**

STRAND MEMORIAL HERBARIUM.

Figure 14-23. *Triticale.*

TRITICALE

Overview and use

Triticale is the product of crossing two closely related species, wheat (*Triticum*) and rye (*Secale*). Triticale combines the characteristics of high yield potential and tolerance to dry conditions from wheat with those of disease resistance and tolerance to low temperature and poor soil from rye. Like wheat, there are winter and spring varieties of triticale, but the winter types generally do not survive winters in Minnesota (Table 14-11).

Triticale is grown as a grain or forage crop. The grain is milled and used in bread and pastry production. Although the protein content is higher than that of wheat, the gluten fraction (the protein that entraps carbon dioxide and causes bread to rise) is less which restricts its use as bread flour.

Triticale grain has a higher protein content than wheat, with slightly higher lysine and threonine (Table 14-12). This, combined with its high starch digestibility, makes it a better feed grain for livestock than wheat. Feeding trials have shown that weight gain for pigs fed triticale-based diets are similar to those fed corn-based diets.

As a component of a rotation, triticale has potential to contribute to reduce risks related to weather, to contribute to soil improvement and increase overall system productivity. However, producers need to establish a market before growing triticale.

Preferred conditions

Triticale yields best on fertile, well-drained soils and in climates suitable to small grain production. However, it tolerates acidic soils and low soil fertility and is better adapted to harsh conditions such as low temperatures or hot, dry weather.

Planting date

Triticale is a cool-season annual. It does well under planting conditions and practices similar to those for wheat. In the North Central region, spring triticale is planted in late April to mid-May. Where practical, winter varieties are planted in the fall, similar to winter wheat.

Planting depth and rate

Triticale is seeded at a depth of one and a half to two inches. A rate of 75 to 100 pounds/acre is seeded to establish a stand of 1,000,000 plants/acre.

Table 14-11. Variety trials of triticale in North Dakota and Iowa.

Yields for North Dakota averaged over four sites and three years (2004-2006) and yields for Iowa are averaged over three sites and two years (2003-2004).

Adapted from Gibson et al., 2005; and Endres and Kandel, 2008.

VARIETY	LOCATION	YIELD (BU/ACRE)
Laser	ND	51
	IA	60
Wapiti	ND	53
	IA	61
Marvel	ND	44
Companion	ND	53
Trical 2700	ND	51
Banjo	IA	50
Pronghorn	IA	72
AC Ultima	IA	67
99 TV 71119	IA	59

DON TANAKA, AGRICULTURAL RESEARCH SERVICE

Figure 14-24. *Harvesting triticale in Mandan, North Dakota.*

Nutrient requirements

Triticale is a moderate feeder. Soil fertility requirements are similar to those of small grains. It requires slightly higher nitrogen levels than wheat and adequate levels of phosphorus.

Pest control

Proper seeding rate, pre-emergence and post-emergence (at the one to three leaf stage) tillage are primary weed control approaches.

Triticale is susceptible to infection by ergot, a fungus that alters the grain appearance and produces toxins. Ergot, scab and rust are common disease problems. Use rotation to avoid these. Insects usually do not cause severe damage.

Harvesting

Harvesting and storage requirements are similar to rye. Triticale can be swathed or straight combined (Figure 14-24). When grown for silage or hay, it should be cut at early-boot stage. Store grain at 13 percent or less moisture.

Table 14-12. Amino acid composition of various crops. *Adapted from USDA-ARS, 2009.*

Crop	*Amino Acid (% of total weight)* Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Tryptophan	Valine	Arginine	Histidine
Dry field pea	1.014	1.760	1.772	0.251	1.132	0.872	0.275	1.159	2.188	0.597
Flax	0.896	1.235	0.862	0.370	0.957	0.766	0.297	1.072	1.925	0.472
Sunflower (kernels)	1.139	1.659	0.937	0.494	1.169	0.928	0.348	1.315	2.403	0.632
Buckwheat	0.498	0.832	0.672	0.172	0.520	0.506	0.192	0.678	0.982	0.309
Triticale	0.479	0.911	0.365	0.204	0.638	0.405	0.157	0.609	0.671	0.311
Proso millet	0.465	1.400	0.212	0.221	0.580	0.353	0.119	0.578	0.382	0.236
Grain sorghum	0.433	1.491	0.229	0.169	0.546	0.346	0.124	0.561	0.355	0.246
Grain amaranth	0.582	0.879	0.747	0.226	0.542	0.558	0.181	0.679	1.060	0.389
Pinto bean	0.871	1.558	1.356	0.259	1.095	0.810	0.237	0.998	1.096	0.556
Navy bean	0.952	1.723	1.280	0.273	1.158	0.711	0.247	1.241	1.020	0.507
Kidney bean	1.041	1.882	1.618	0.355	1.275	0.992	0.279	1.233	1.460	0.656
Soybean	1.971	3.309	2.706	0.547	2.122	1.766	0.591	2.029	3.153	1.097
Corn	0.337	1.155	0.265	0.197	0.463	0.354	0.067	0.477	0.470	0.287
Wheat hard red spring	0.541	1.038	0.404	0.230	0.724	0.433	0.195	0.679	0.702	0.330
Oats	0.694	1.284	0.701	0.312	0.895	0.575	0.234	0.937	1.192	0.405
Barley, hulled	0.456	0.848	0.465	0.240	0.700	0.424	0.208	0.612	0.625	0.281

Reducing risk: triticale. **Triticale has better disease resistance than wheat, but newer varieties should be planted and rotated with crops other than small grains to minimize problems with ergot. Straight cutting rather than swathing will reduce risk of pre-harvest sprouting.**

Alternative crops in a corn and soybean rotation

Crop diversification by including crops other than corn and soybean can be a powerful tool by which farmers can reduce weed populations and gain rotation benefits. Research was conducted to determine how alternative crops responded within a corn and soybean rotation. Alternative crops were grown in rotation either following corn or soybean. Field experiments were conducted at Lamberton, Waseca, and Rosemount, MN, in 2006 through 2008.

The previous crop did not have a large effect on the alternative crops' yields (Tables 14-13 and 14-14). Instead, it was found that weeds and weather conditions were the largest risks. Amaranth and flax suffered due to lack of effective weed control. Dry, warm conditions also took its toll on flax yields in some years. Other alternative crops such as sunflower performed more competitively. Growers should be aware that some alternative crops will have greater production risks than others.

Table 14-13. Alternative crop yields after soybean averaged across locations and years

CROP	MEAN YIELD	RANGE OF YIELDS (BU/ACRE)
Amaranth	18	0 to 45
Buckwheat	19	8 to 39
Flax	10	0 to 24
Spring wheat	26	12 to 33
Sunflower	90	33 to 140
Proso Millet	20	6 to 49
Oat	46	17 to 73

Table 14-14. Alternative crop yields after corn averaged across locations and years

CROP	MEAN YIELD	RANGE OF YIELDS (BU/ACRE)
Amaranth	15	0 to 47
Buckwheat	24	6 to 39
Flax	5	0 to 22
Spring wheat	26	14 to 42
Sunflower	91	41 to 141
Field Pea	28	8 to 52
Grain sorghum	58	43 to 89

Figure 14-25. *Alternative crops trial, 7-9-08.*

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Figure 14-26. *Proso millet.*

DAVID L. HANSEN

Figure 14-27. *Foxtail millet.*

MILLETS

Overview and use

The term 'millet' is used to refer to several different grass species that are grown for grain production. They include proso, foxtail, barnyard (or Japanese), browntop, and pearl millet. The most commonly grown types of millet in the North Central region are proso millet and foxtail millet (Table 14-15). Proso millet grain can be used in livestock feed and compares nutritionally to oats and barley. It is also used in caged and wild bird feed mixes. Foxtail millet is used for hay or silage. Proso millet can yield 2,500 to 2,800 pounds/acre of grain. Foxtail millet can yield three to four tons/acre of forage.

Table 14-15. Proso millet variety trials.
Yields are an average of four sites in North Dakota. Adapted from Endres and Kandel, 2009.

VARIETY	YIELD (LB/ACRE)
Horizon	1368
Sunrise	984
Sunup	1244
Red Waxy	424

Preferred conditions

Both proso and foxtail are annual, short-season grasses. They mature rapidly and use water efficiently. Consequently, they can often avoid late summer drought and moisture deficits that occur on sandy soils. Millets do not tolerate poorly-drained soils. Soil pH should be at 5.6 or higher.

Planting date

Proso millet matures in 70 to 100 days. Foxtail is ready to harvest in about 50 to 65 days from emergence. Millets need warm soil temperatures (68 to 86° F) for germination and growth and do not tolerate frost. Millets are generally planted mid-June to mid-July in the North Central region. Later seeding reduces yields and increases the risk of exposure to early frost.

SCOTT BAUER, AGRICULTURAL RESEARCH SERVICE

Figure 14-28. *Planting foxtail millet.*

Planting depth and rate

Seed proso millet at 20 to 30 pounds/acre and foxtail millet at 15 pounds/acre at a one-inch depth (Figure 14-27). Millets do not compete well with weeds so a high seeding rate should be used when heavy weed competition is expected. Seedbed preparation is similar to that for small grains. A grain drill with press wheels is recommended to ensure a firm seedbed and good emergence.

Nutrient requirements

Adequate nitrogen, phosphorus and potassium levels are essential for optimum yield. Excess nitrogen can result in lodging.

Pest control

Similar to small grains, a clean seed bed is important for emergence and early establishment. Because of their late planting date, there is ample time for mechanical weed control operations prior to planting. Avoid excessive tillage to conserve soil moisture.

Millets are susceptible to head smut, kernel smut, and bacterial stripe disease. Rotation is the best control.

Harvesting

Timing of harvest is important. Proso millet can be harvested when the seeds on the upper half of the panicle are brown and no longer soft. Shattering and lodging increase when harvest is delayed. Millet should be swathed prior to combining to allow straw to dry. Foxtail millet is cut at late boot to late bloom stage for forage. If it has been heat or water stressed it can accumulate nitrate to levels dangerous to livestock and should be checked prior to feeding. For storage, millet seed should be at 13 percent moisture or less.

Reducing risk: millets. **Plant before June 25 if growing millet for seed. Excessive nitrogen can result in lodging. Rotate crops to control smuts. Time harvest properly for best yields.**

CAMELINA

Camelina, a member of the mustard family, is a hardy oilseed crop that shows better drought tolerance and greater freezing tolerance than canola or soybean. The plants are heavily branched, growing to heights of 1 - 3 feet loosely resembling canola or flax. Camelina oil has unique properties very high in alpha-linolenic acid (ALA), an omega-3 fatty acid which is essential in human and animal diets.

Camelina is a cool season crop that produces greatest yields when sowed early. Seed is simply broadcast, or drilled, at rates of 6 to 8 lbs/acre and requires only modest amounts of fertilizer. Camelina has been promoted as a low-input, low-fertility crop, but yields may increase with total soil N up to 80 lbs N/acre. Crop harvest is similar to small grains or canola and does not require any specialized equipment.

Two organic dairy farmers in northwest Minnesota are experimenting with camelina as an alternative crop and using it to replace soybean meal in their dairy rations. Following harvest, the oil is extruded at a local feed mill providing these farmers with meal containing 40% crude protein and 10-12% oil. In their initial on-farm feeding trials, milk production increased slightly when substituted for the equivalent rates of organic soybean meal. However, camelina meal reportedly contains anti-nutritive compounds called glucosinolates which may limit the inclusion rate. No problems were found with palatability or acceptance. These farmers find that camelina is easy and inexpensive to grow, competes well with weeds, and may provide another option to soybean meal in organic dairy rations.

GRAIN SORGHUM

Overview and use

Grain sorghum is used mostly for livestock feed and it has similar nutrition to corn. Grain sorghum feed values are 90 to 100 percent that of corn. It is often grown in areas that are too hot and dry for corn production. Grain sorghum can be mixed with soybeans to produce a high protein silage.

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Figure 14-29. *Grain sorghum.*

Preferred conditions

Cool temperature is the most limiting factor to sorghum production in the North Central region. Grain sorghum requires average (day + night temperature average) temperatures of 80° F. Maximum photosynthesis occurs at about 90° F. Thus, sorghum is best adapted to the southern part of Minnesota. Cool temperatures (below 55° F) during heading and pollination will reduce seed set. Early maturing hybrids of 80-85 day relative maturity are recommended for the North Central region.

Sorghum tolerates short periods of drought better than corn. Tillering will compensate for lower planting populations. It also tolerates wet soils and flooding better than other grains. It tolerates saline soils better than corn.

In dry years, sorghum offers the following advantages over corn production: self-pollination reduce the risk of poor seed set; sorghum's tillering capacity results in yield potential that can be supported by moisture levels; the waxy material on sorghum leaves contributes to greater water use efficiency. Yields can reach over 100 bushels/acre. Sorghum often produces higher yields than corn in dry conditions, but corn will out-yield sorghum under moist and fertile conditions.

Planting date

Soil temperatures should be in the range of 60 to 65° F for maximum emergence after planting. This typically occurs between May 15 and early June. It takes 80 to 120 days to mature depending on the variety. Seedlings can be slow to emerge.

Planting depth and rate

Plant one inch deep in heavy soils, one and a half to two inches in sandy soils. On fertile, moist soils, plant at eight to ten pounds/acre in rows 30 to 40 inches wide for a final plant population of 100,000 to 120,000 plants/acre. Studies with narrow rows (10-inch) in Minnesota showed improved yields in wide rows compared to narrow rows. Because cultivation is not possible with narrow rows, this option is less attractive for organic systems. On dry, less fertile soil, a lower seeding rate, five to six pounds/acre, should be used.

Nutrient requirements

Fertility requirements for grain sorghum are similar to corn. Adequate nitrogen, phosphorus and potassium are particularly important.

Pest control

Prepare the seed bed in early spring followed by one or more cultivations. Sorghum competes poorly with weeds during early emergence. Cool soil will result in slow establishment and give early weeds an advantage. After planting, sorghum can be cultivated prior to emergence and up to 6 inches tall.

Disease and insects generally are not problematic.

Harvesting

Sorghum is harvested when grain moisture is 20 to 25 percent. A frost will help grain to dry. Sorghum is harvested with a combine. Store at a moisture level at or below 13 percent.

Reducing risk: grain sorghum. Choose earlier maturing varieties. Grow grain sorghum only in areas to which it is adapted.

Figure 14-29. *Amaranth.*

GRAIN AMARANTH

Overview and use

Amaranth is a grain that is high in protein and lysine, the essential amino acid lacking in cereal grains. It is used as a grain crop and leafy vegetable and has potential as a forage crop. The grain is ground and the flour used in many products including noodles, pancakes, and pastries.

Two species of grain amaranth are grown. The most common variety is ‘Plainsman’.

Preferred conditions

Amaranth is adapted to a wide range of conditions and is grown throughout the Midwest. It performs well on lighter soils and on slightly acidic to basic soils. It tolerates drought and heat.

Planting date

Plant in late May to early June, or when the soil temperatures are 65° F. With the short summers in the Upper Midwest, planting as early as feasible may increase yields (Table 14-16).

Planting depth and rate

Seeds of amaranth are extremely small so seedbed preparation is important. Fields should be worked with a cultivator or disk and prepared using a cultipacker or harrow. Seeds are planted one-half inch deep using a planter with press wheels. Planting depth depends on soil type and moisture conditions. Emergence is generally low and is reduced on heavy soils. Plant amaranth at rates of between one half to two pounds/acre. Trials in Minnesota showed the best yields were obtained at planting rates between 1.6 and 4 pounds/acre.

Nutrient requirements

Amaranth has fertility requirements similar to sunflower. Phosphorus and potassium should be in the medium to high range.

Table 14-16. Management practices effects on amaranth production.
Research in eastern Canada found that many management practices had little significant effect on yield. Planting early, however, did positively affect yields. Adapted from Gelinas and Seguin, 2008.

MANAGEMENT PRACTICE		YIELD LB/AC
Seeding date	Mid-May	856
	Early June	777
	Mid-June	718
Cultivar	K432	756
	K593	718
	Plainsman	878
Seeding rate (lbs/acre)	0.9	781
	1.8	832
	3.6	817
Row spacing (in.)	15	820
	23	800
	30	809
N-rate (lbs/acre)	0	854
	45	871
	89	844
	134	916
	178	896

Pest control

Amaranth is very susceptible to competition from weeds. Therefore, it is essential to include it in a crop rotation that minimizes weeds seed bank development. Seedlings grow slowly, so three to four cultivations may be necessary. Avoid planting this crop in lambsquarter or pigweed infested fields. Grain amaranth usually does not become a weed in following crops.

Disease issues are rare. The tarnished plant bug is sometimes a problem.

Harvesting

Over 1,000 pounds per acre can be obtained in the Midwest, but some seed can be lost to shattering. Amaranth should be exposed to a killing frost (which functions as a desiccant) before harvest, followed by seven to ten days of good drying weather. High moisture grain will cause problems with the combine. Because of the small seed size, cleaning the grain is important. Store at 11 percent moisture.

Reducing risk: Amaranth. Use rotations that reduce weed populations. Avoid planting amaranth in heavy soils. Harvest carefully to minimize lost seed. Late planting dates may lead to more difficulties in harvesting and storage due to increased grain moisture.


STRAND MEMORIAL HERBARIUM

Figure 14-31. *Field beans.*

FIELD BEAN

Overview and use

Like soybeans, field beans are warm season annual legumes. Market classes of field beans include black turtle, cranberry, great northern, kidney, navy, pink, pinto, small red, and small white. Pinto, navy and kidney are the most widely cultivated species. They are produced for human consumption and are purchased in dried, canned or cooked forms. They are the second most important legume in the world (soybeans are first) in terms of amount produced. Beans must be cooked to destroy an inhibitor that prevents the trypsin enzyme from breaking down protein in the digestive track of non-ruminants.

Determinate and indeterminate (vine) types may be found depending on the market class. Indeterminate types produce new vegetative growth at the same time as they produce flowers.

Preferred conditions

Field beans will do best in areas with 14 to 20 inches of rainfall. Overly humid conditions will lead to disease. Fertile sandy, well-drained loam soils with a pH between 5.8 to 6.5 are best. Above a pH of 7.2, iron and zinc deficiencies in some varieties can result in chlorosis. Soils that are temporarily flooded, easily compacted, or form a crust are not suitable.

Planting date

Plant after all danger of frost is past, between May 15 and 26. Field beans require between 85 to 120 days to mature. They do best when temperatures range from 50 or 60° F for lows to 80° F for highs. When planted early, flowering and pod set occur in early July, before the period of high temperatures and reduced moisture. Early planting also allows harvest to be completed before fall rains.

Planting rate and depth

Planting rate varies from 75,000 to 105,000 seeds/acre and depends on seed size, growth habit, germination rate, and soil conditions (Table 14-17). Narrow rows are preferable. Plant between one to two inches deep.

Nutrient requirements

Good fertility is required to obtain high yields. Although field beans fix atmospheric nitrogen, effective nodulation by *Rhizobium phaseoli* is difficult in some soil types and under some environmental conditions. Inoculation is recommended. In some cases, nitrogen fertilization can be used to enhance yields. A soil test should be performed to determine that other nutrients are in the recommended range. Micronutrient deficiencies can occur. Field beans require relatively high levels of manganese.

Pest control

Field beans are not competitive with weeds. The late seeding date will allow multiple cultivations of early germinating weeds. Mechanical weed control should be

Table 14-17. Planting rates for different bean types. *Adapted from Hardmann et al., 1990.*

CLASS	RATE (lb/acre)	RATE (seeds/acre)
Black Turtle	45	105,000
Cranberry	85	105,000
Great Northern	100	105,000
Kidney	90-115	105,000
Navy	30	105,000
Pink	60	105,000
Pinto	60-80	105,000
Small Red	75	78,000
Small White	35	78,000

completed before bloom, after about five to six weeks of crop growth.

Field beans are susceptible to potato leafhopper and aphids; however, no organic control measures exist for these insects.

Harvesting

Yields average between 1,200 and 2,000 pounds/acre. Field beans are cut, windrowed and then combined (Figure 14-33). Cutting when humidity is high will reduce shattering. Combining beans directly can result in significant losses and seed damage. Store at 16 to16.5 percent moisture.

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Figure 14-32. *Pinto beans before harvest.*

Reducing risk: dry beans.

High quality seed is a priority for optimum growth. Disease resistant varieties should be used and residue left in the field should be buried to reduce disease incidence in subsequent years. Mottled beans like pinto may be less risky to grow because of fewer issues with off markings that can occur with white beans.

Conclusion

Alternative crops can be good additions to organic systems. Producers need to carefully consider markets and production requirements before adding a new crop to their rotations. Take the following quiz to determine your risk.

Alternative Crops Risk Management Quiz

	Points	Score
1. What is your primary reason for growing alternative crops or what do you hope to accomplish?		
Higher income	1	
Grow feed for own livestock	5	
Diversify system	5	
Improve soil	3	
Improve pest situation	3	
2. Which of the following resources do you have to support production of this alternative crop? Choose all that apply.		
Proper equipment	1	
Time and labor	1	
Ideal field conditions	1	
Financial stability	1	
Market	1	
Seed source	1	
3. Do you presently have any crops that can be considered an alternative crop in your rotation?		
Yes	5	
No	0	
4. Do you personally know someone who grows this crop?		
Yes	3	
No	0	
5. Has the crop been proven to be adapted to your conditions?		
Yes	5	
No	0	
Not sure	0	
6. Which of the following do you know about the growing requirements of this alternative crop? Choose all that apply.		
Fertility requirements	1	
Climate requirements	1	
pH requirements	1	
Moisture requirements	1	
Soil drainage requirements	1	
7. Does the alternative crop require new or specialty equipment?		
Yes	0	
No	2	
Not sure	0	

	Points	Score
8. Does the production schedule of the alternative crop complement your existing production schedule (i.e. is there little overlap in tasks?)?		
Yes	5	
No	0	
Not sure	0	
9. Do you plan to sell this alternative crop?		
Yes	0	
No, I will use on-farm	5	
If you answered "No" to Question 9, skip Questions 10 - 16.		
10. Is there infrastructure for transportation to available markets?		
Yes	5	
No	0	
Not sure	0	
11. Which of the following best applies to this crop?		
Existing market is relatively stable	3	
Market potential is emerging	1	
Not sure	0	
12. Which of the following best applies to this crop?		
Markets are available, but no contracts	1	
Contracts are available	3	
Direct marketing is a valid option	1	
None of the above	0	
Not sure	0	
13. At what level does the market for this crop operate?		
The crop has a local market	3	
The crop is sold to markets in other states	2	
The crop is sold to buyers overseas	1	
Not sure	0	
14. Do you know the market requirements for the crop?		
Yes	3	
No	0	
15. Do you know which varieties are suitable for your market?		
Yes	3	
No	0	

Alternative Crops Risk Management Quiz, continued

	Points	Score
16. Do you have a backup plan if the buyer requirements are not met?		
Yes, I have places to sell as feed	3	
Yes, I can use myself as feed	5	
No, I will need to investigate	0	
17. Do you have options for storing the crop?		
Yes	3	
No	0	
18. Have you lined up a seed source?		
Yes	3	
No	0	
19. Have you investigated start-up funds for your crop?		
Yes	3	
No	0	
20. Do you have an idea of how your yields may compare to typical yields?		
Yes	3	
No	0	
21. Have you assessed production costs and compared them to your expected yields and market prices?		
Yes	5	
No	0	
22. Have you researched prices and trends for the alternative crop in question over at least the last three years?		
Yes	5	
No	0	
23. Does the alternative crop fit well into your existing rotation?		
Yes	5	
No	0	
Not sure	0	
24. How vigorous is the alternative crop relative to weeds?		
Very competitive	5	
Somewhat competitive	3	
Not competitive	0	

	Points	Score
25. Does the alternative crop have potential to become a weed in your row crops?		
Yes	0	
No	3	
Not sure	0	
26. Is there potential for poor weed control in the alternative crop that could lead to increased weed issues in general?		
Yes	0	
No	2	
Not sure	0	
27. Will the alternative crop be a host for disease or insect pests that afflict your cash crops?		
Yes	0	
No	3	
Not sure	0	
28. Do you have access to additional labor if necessary for the production of the alternative crop?		
Yes	2	
No	0	
Not applicable	2	
29. Have you grown the alternative crop in small-scale plots?		
Yes	5	
No	0	
30. Have you tried multiple varieties of the alternative crop if available?		
Yes	5	
No	0	
Not applicable	3	
	TOTAL	

If you answered Questions 10 - 16

And your score is:	Your risk is:
39 or less	High
40 - 70	Moderate
71 or greater	Low

If you did NOT answer Questions 10 - 16

And your score is:	Your risk is:
39 or less	High
40 - 55	Moderate
56 or greater	Low

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