HISTORY
Camelina (Camelina sativa L.) was first cultivated in northern Europe during the Bronze Age. Seeds were crushed and boiled to release oil for food, medicinal use, and lamp oil, and seeds were also eaten without processing. Camelina is native from Finland to Romania and east to the Ural Mountains. Although it was widely grown in Europe and Russia until the 1940s, camelina was largely displaced as higher-yielding crops became available after WWII. Its decline in Europe was accelerated by farm subsidy programs that favored the major commodity grain and oilseed crops and high yields.

Camelina is a relatively common weed in much of Europe and is known as false flax or “gold-of-pleasure.” “Siberian oilseed” is another rather accurate, descriptive common name. Very little crop improvement or agronomic work had been done on camelina until recently, and its full potential has not yet been explored, particularly in North America. With rising interest in vegetable oils high in omega-3 fatty acids, camelina production has increased somewhat in recent years.

A major effort is under way in Montana, Oregon, some other northwestern states, and Alberta, Canada, to produce camelina on a large scale under dryland conditions. Interest in expanding camelina production include uses as a low-cost feedstock for biodiesel and a premium meal value-added product for animal feed that can be used to produce high omega-3 eggs, broilers, or dairy products. Camelina meal has recently been approved for feeding to broilers and beef at levels up to 10 percent.

DESCRIPTION
While camelina is generally grown as an early summer annual oilseed crop, it can be grown as a winter annual in milder climates. In our limited experience, it failed as a winter annual in northwestern Pennsylvania but has overwintered in southwestern Pennsylvania. Camelina is a short-season, cool climate adapted crop that matures in 85–100 days, comparable in development and maturity to oats. Seedling leaves are small and covered with hair, much like mouse-eat chickweed. The plants grow 12–36 inches tall and have branched stems that become stiff as they mature. Their leaves are 2–4 inches long, arrow shaped, and pointed with smooth edges. Camelina produces seed pods that resemble flax bolls, small, pea-sized round pods with over a dozen seeds in each. The seed pods form in the upper portion of the plant, well off the ground. Unlike some other members of the Brassica genus, camelina pods do not open easily to allow seed dispersal, and seed losses from shattering before and during harvest are minimal. Camelina seeds are quite small (timothy seed size) with a typical seed weight around 400,000 seeds per pound (range of 225,000–550,000 seeds per pound). There is no known seed dormancy in camelina, and seed lost during harvest generally germinates soon thereafter.
ADAptAtion
Camelina is a short-season crop (85–100 days) that is well adapted to production in the temperate climatic zone. It germinates at low temperature, and seedlings are very frost tolerant. No seedling damage has been seen at temperatures as low as 12°F in Montana. The plant performs well under drought stress conditions and may be better suited to low rainfall regions than most other oilseed crops. It should do very well on our coarser textured or shallow, droughty soils. However, in initial trials in Pennsylvania it has not performed well on wet and poorly drained soils.

Camelina also appears to be well adapted to no-till in soybean or small grain stubble. Establishment may be spotty in areas of heavy soybean residue. Camelina seems to perform well as a companion crop (instead of oats) in establishing legumes for green manure cover and/or forage.

VARIETY SELECTION
Since only limited plant breeding has been done on camelina, few commercial varieties have been released in the United States. In France, Group Limagrain has released the spring variety Celine (and the winter variety Epona). Montana State University recently released two new public varieties: Blaine Creek and Suneson. Blaine Creek is described as a short-season, high-yield line particularly adapted to high-yield environments. It is also high in omega-3 fatty acids. Suneson is described as a midseason, average-yield line; it is typically 2–3 percent higher in oil content than Blaine Creek. Suneson is also higher in alpha-linolenic acid (C18:3n3). Another variety, Cheyenne, from Blue Sun Biodiesel in Colorado, has been used successfully as well in Pennsylvania. A number of companies are working on developing other varieties.

SEEDING
Ideal seeding rates for camelina are 3–5 pounds of pure live seed per acre. Camelina production should be targeted to fields with low weed pressure since there are no herbicide options for camelina. Seed should be drilled very shallow, as shallow as possible, with a grain drill. Ideally, some seed should be observed on the soil surface. The low seeding rate will likely require the use of the forage (grass) seed box at low (nearly closed) settings. It can be broadcast seeded, but like most broadcast seedings, uniformity can be an issue. Either true frost seeding into honey-combed surface soil or following some slight surface disturbance before broadcasting, followed by packing after broadcasting seed, may help. In Europe, camelina is normally seeded at 6–8 pounds per acre, but recent trials in Montana indicate that 2.5–3 pounds of seed per acre can produce adequate crop stands.

Camelina generally has the ability to germinate with minimal rainfall and establishes quickly. The crop should be planted as early as possible in the spring—as is recommended for oats and/or cool-season forage seedings. Begin seeding when soil temperatures reach 38–40°F in the spring. Camelina is very resistant to frost as a seedling, and stand losses have not been observed at temperatures as low
as 20°F. It is important to be ready to take advantage of any early seeding opportunities. In other regions, later plantings have shown yield losses of about 100 pounds per week of delay. Soybean stubble is the preferred seedbed, but be careful to consider the injury potential of previous herbicide applications with long residual materials. For example, the active ingredient sulfentrazone (Authority/Spartan) is extremely active on camelina. Camelina can also be planted following corn or small grain stubble. No-till seeding into sods has resulted in mixed success. Some reports indicate camelina should not be planted following buckwheat.

**SOIL FERTILITY**

Fertilizer can be applied prior to planting or included with the seed if broadcasting. Camelina has generally low fertility requirements. Typical recommendations from Montana are 35–40 pounds of nitrogen (N) where yields ranging from 1,200–1,500 pounds per acre are expected and 40–50 pounds per acre where higher yields are expected. In addition, a recommendation for 25–30 pounds P (phosphorus) (P₂O₅) per acre and 20 pounds S (sulfur) per acre may be justified in some situations. Ammonium sulfate (21-0-0-24S) at 100 pounds per acre could supply the sulfur needs and provide 21 pounds N per acre. Camelina has a natural pale green color, which should not necessarily be interpreted as a nutrient deficiency. Also, as it develops, camelina will seem to almost stall in the rosette phase and then elongate and branch (preflowering) in a very short time. The crop adapts very well to environmental conditions and can have multiple successive “miniblooms” as moisture and environment allow.

**WEED CONTROL**

The crop is naturally competitive with weeds, and early establishment of good camelina stands has resulted in minimal weed competition. European research has shown camelina to generate chemical compounds that suppress weed growth, and many weeds are suppressed until leaf drop occurs in the crop. The herbicidal effect of camelina is short lived and relatively weak and does not affect the next year’s crop. Early seeding of spring camelina into clean fields should result in minimal weed problems. Poast (a postemergence grass control product) was recently labeled for camelina and is the only herbicide labeled to date. More herbicides should be labeled in the future. A harvest-aid weed desiccation application may be necessary before direct combining.

**DISEASE AND INSECT CONTROL**

Few or no insects appear to cause damage to camelina. Flea beetles and common aphids, which can be pests in canola (and mustards), do not seem to bother camelina. Downy mildew (fungus) is a concern and has been found in some experimental trials. No downy mildew has been observed east of the Continental Divide. White mold has not been observed in camelina in Montana, but growers should monitor for white mold as it is a disease common to brassicas such as canola and members of the sunflower and legume families. It typically is found in higher moisture environments. Camelina is also highly resistant to blackleg (*Leptosphaeria maculans*), a major disease of canola and other brassica crops.

**HARVESTING AND STORAGE**

Harvest of early planted camelina typically occurs in July. Camelina can be harvested with unmodified combines and may be direct combined standing or swathed. Generally, growers should expect to take the crop standing. The crop ripens within a few days. Barring high wind damage, the crop can be left to stand until pods are a straw to tan color. This occurs within days of the first yellow coloration of pods in the field. Seeds ripen quickly during color change. Swathing is recommended if lodging occurs or there is a significant amount of green weed material in the field. Swathing should be started when about two-thirds of the pods turn from green to yellow. Mature pods are dark tan or brown. Unlike many brassicas, camelina pods hold their seeds tightly, and seed shattering is not generally a problem.

Green weeds present at harvest may require a harvest-aid desiccation application for direct combining. Combine settings similar to those used for canola or alfalfa seed work well with camelina; however, combine fan speed may need to be reduced to minimize seed losses. Camelina is a remarkably adaptable crop, and pods are located in the upper half of the canopy, making combining easier. If direct cutting, reel speed should match ground speed. Keep ground speed slow enough to prevent throwing camelina seed over the back of the combine head. Header height can be set fairly high to minimize green material moving through the combine. In one trial, header losses of about 3 pounds per acre (or about 27 seeds per square foot) were observed.

Seed on the soil surface lost during harvest typically germinate with the first rain. With seed able to germinate almost immediately, at least one grower has taken advantage of this and actually produced and harvested a second (“double”) crop. Otherwise, volunteer camelina can be handled by fall weed control or by leaving it in the field, where it will winter kill. In mild winters, spring camelina can survive and be controlled easily in the crop that follows. Camelina straw is tough and should be minimized during harvest. Some sources recommend that a ¼-screen be installed over the lower sieves to allow seed separation from seed capsules. However, we have had good success even with deep-toothed (corn-soybean) sieves closed down. Attempts to manipulate air by cutting flow to a minimum have been effective. This technique leaves a very high residue of inert materials in the bin. Growers should try to keep inert materials to less than 5–8 percent. Further cleaning is generally recommended before crushing to prevent damage to the presses.

A moisture sample should be taken at the start of harvest. Harvest should proceed only when seeds are 10 percent moisture or less using a canola standard in a moisture meter. The field may still contain some green stems at this point. Camelina seeds are surrounded by a light mucilage
layer that easily absorbs moisture. While this layer aids in seed germination (much like a super slurper), it is detrimental to seed storage. Seed stored at high moisture can sweat and stick in a bin if moisture exceeds 10 percent. Ideally, seed should be stored at 8 percent moisture or less. Storage in perforated floor bins covered with window screen type mesh allows air treatment to ensure safe storage. Camelina has not been observed to be eaten by rodents or insects, so bin treatments are currently unnecessary. Camelina seeds have a rough surface and are not as easily lost as canola or flax seed, but they are quite small, so leaks in equipment should be sealed to reduce seed losses during harvest and transport.

**YIELD PERFORMANCE**
Camelina has yield potential similar to that of many other members of the *Brassica* genus. Studies at the University of Idaho in 2005 and 2006 near Moscow in a 24-inch rainfall area indicate a yield advantage for camelina compared to canola and mustard. While the yields of other brassicas have been significantly increased in recent decades through plant breeding and agronomic improvements, the potential of camelina remains unexploited.

Under dryland conditions in Montana, camelina is expected to yield 1,800–2,000 pounds of seed per acre in areas with 16–18 inches of precipitation and 900–1,700 pounds per acre with 13–15 inches of rainfall. In Idaho, seed yields of 1,700–2,200 pounds per acre have been reported in the 20–24 inch rainfall area. Under irrigation, seed yields of 2,400 pounds per acre have been reported. Three years of yield data at Moscow, Idaho, show a seed yield potential of 2,100–2,400 pounds per acre with 25 inches of rainfall. In northwestern Pennsylvania in 2008, our best yields ranged from 1,000 to 1,500 pounds (20–25 bu) per acre, but none had any commercial fertilizer applied. In 2009, most producers applied urea at 100 pounds per acre, but yields were similar to those from 2008. Excessive nitrogen (application overlaps) caused some lodging.

**USES AND ECONOMICS**
Camelina oil has desirable characteristics as a feedstock for biodiesel. Efforts are under way to further that development. Camelina oil is relatively high in omega-3 fatty acids and low in saturated fatty acids. Consequently, it would appear to have good potential as an edible oil. In addition, the oil contains gamma tocopherol (vitamin E), which acts as an antioxidant and increases the oil’s stability compared to other omega-3 oils. Like canola and other brassicas (like broccoli, cauliflower, and brussels sprouts), camelina has sulfur-containing compounds called glucosinolates. It also contains erucic acid (22:1), a compound of regulated levels for canola.

For these reasons, the meal market is currently limited, with only certain specified recent approvals for feeding. Further testing and research analyses are required and ongoing for potential additional approvals. Camelina meal, as approved, will compete primarily with the flax (or linseed oil) markets, again due to the omega-3 oils it contains. Recent feeding trials at Penn State have confirmed that it can be used in poultry rations as a substitute for flax. Promising refinements of existing commercial technologies that enable the isolation and extraction of camelina’s oil components could have a significant positive economic impact. The value is theoretically comparable to that of canola (10–20 cents per pound or $5–$10 per bushel).

Camelina is a novel crop with unique and promising properties for high-value uses beyond the existing oil market as a biofuel feedstock. At this point, it is primarily a developing and experimental market. Growers should identify a market for the crop before producing. Like other oilseed crops, camelina offers some rotational and legume cover cropping opportunities that should help justify its economic competitiveness and inclusion in our rotations. As an early harvested spring crop, a red clover or other legume cover crop could be planted following harvest to provide nitrogen and prepare a field for corn production in the next year. One producer has experimented with seeding a mixture of camelina and clover. The camelina grew rapidly and suppressed the clover until after harvest, and then the clover was released and produced a crop for a fall harvest.