



NORTH
STATE

Safflower Production

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Utilization and Description

Safflower (*Carthamus tinctorious* L.) is an annual oilseed crop adapted primarily to the cereal grain areas of the western Great Plains. In North Dakota, safflower has been grown in experimental test plots since 1928 and on a commercial basis since 1957. Acreage has been concentrated in the western part of the state. Safflower is well adapted to drier areas of North and South Dakota as well as Montana.

Safflower provides three principle products: oil, meal, and birdseed. Safflower oil is used by both food producers and by industry. There are two types of safflower oil with corresponding types of safflower varieties: those high in monounsaturated fatty acid (oleic) and those high in polyunsaturated fatty acid (linoleic). Currently the predominant oil market is for those varieties that produce seed high in oleic acid and very low in saturated fatty acids. High oleic safflower oil is lower in saturates and higher in monounsaturates than olive oil. High oleic oil is a beneficial agent in the prevention of coronary artery disease. Oil from this type of safflower is used as a heat stable cooking oil to fry such food items as french fries, chips and other snack items and is also used in cosmetics, food coatings, and infant food formulations. High linoleic safflower oil is also used in human nutrition, but in recent years market demand

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has drastically shifted from the traditional high linoleic oils to high oleic oil. High linoleic oil is valued as a drying agent in paints and varnishes because of its non-yellowing characteristic. The meal, which is about 24 percent protein and high in fiber, is used as a protein supplement for livestock and poultry feed. Safflower seed is also marketed as birdseed. This industry prefers the white hull or normal hull type of safflower even though striped and partial hull types are usually higher in oil and protein content. There currently is no preference as to fatty acid type. Safflower also makes an acceptable livestock forage if cut at or just after bloom stage.

Safflower is a thistle-like plant with a strong central branch stem, a varying number of branches, and a tap-root system. Each branch will usually have from one to five flower heads containing 15 to 20 seeds per head. The seed oil content ranges from 30 to 45 percent. Flower color is usually yellow or orange, although some varieties have red or white flowers. Plant height in North Dakota varies between 15 and 30 inches depending on environmental conditions. The taproot of safflower can penetrate to depths of 8 to 10 feet if subsoil temperature and moisture permit. As a result, safflower is more tolerant to drought than small grains.

Safflower is typically sown in April or early May. Seedlings generally emerge in one to three weeks.



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Early seedling growth and development is slow. A young plant spends two to three weeks in the "rosette" stage while growing leaves. Temperatures as low as 20 degrees Fahrenheit are tolerated by safflower while in the rosette stage. Safflower is very susceptible to frost injury from stem elongation to maturity. Safflower has potential as an alternative forage in the event of an early killing fall frost before crop maturity. Relative forage value peaks at or just after bloom stage and decreases in relative forage value as the safflower reaches maturity. In 1993, when safflower failed to mature due to unusually cool, wet growing conditions and earlier than normal fall killing frosts, farmer testimonials indicated that dry matter yields ranged from 1 to 3 tons per acre and quality analyses showed that safflower hay had 8 to 10 percent crude protein with acceptable fiber levels. In 1994 Montana trials, relative feed values of safflower peaked at 168 for high yielding environments and 233 for low yielding environments.

Plants begin forming floral buds in late June and flower in mid to late July. The bloom stage usually lasts 14 to 21 days, depending on stand density, available moisture and variety. The crop matures about four weeks after flowering ends. In North Dakota, safflower normally requires from 110 to 140 days from seeding to maturity.

Safflower grows best on deep, fertile, well-drained loam soils with good water-holding capacity. It can also thrive in coarser-textured soils of lower water-holding capacity when rainfall amount and moisture distribution are adequate. Safflower is similar to barley in tolerance to saline soils. Soil salinity, depending on severity, will lower germination and decrease seed yield and oil percentage of the seed. It is an excellent crop to grow in recharge areas because its deep tap root system uses surplus water during its long growing season. Do not plant safflower on poorly drained land.

In North Dakota the crop is best adapted west of a north-south line through Minot and Bismarck. In this area, dry atmospheric conditions usually prevail during the blossoming and seed-filling stages. East of this line higher humidity and morning dew increases leaf and head diseases and reduces seed set, both of which can reduce yields.

Rotation

Safflower is most often grown on fallow or in rotation with small grains. Volunteer grain from the previous crop may be a problem when safflower follows cereals. Adequate fall rains and tillage will encourage germination and reduce volunteer small grain problems in the next year's crop.

Safflower should not follow safflower in rotation or be grown in close rotation with other crops susceptible to the disease sclerotinia (white mold). These crops include dry bean, field peas, sunflower, mustard, crambe, and canola/rapeseed. In any cropping sequence involving safflower, a crop following safflower should be sown only if there has been a significant recharge of soil moisture. There is very little crop residue remaining on the land after a safflower crop is harvested, leaving the soil susceptible to wind and water erosion the next fallow year. Reduced tillage and/or chemical fallow may be advisable to preserve trash and reduce erosion.

Planting Dates, Rates, Row Widths

Optimum planting dates for safflower are between April 20 and May 10. Early planting allows the crop to take full advantage of the entire growing season. Planting prior to April 10 shows no advantage since cool soil temperatures (below 40 F) prevent germination and encourages seedling blight. Planting after May 20 increases the risk of fall frost injury and disease that reduce seed yield and quality. Delayed planting may delay harvest to the point where mechanical drying of the seed is necessary. Late planting generally results in shorter plants, decreased branching, and lower seed and oil yields, even if frost damage does not occur and/or disease incidence is low.

Use high quality seed that has good germination (above 80%) and is treated for prevention of seedling

diseases. Safflower seedlings are not vigorous. Soil crusting can be a major deterrent to adequate stand establishment. Planting depths of 1 to 1.5 inches are optimum. Recommended seeding rates are from 20 to 30 pounds per acre of pure live seed. Lower seeding rates will result in branches lower to the ground, delayed maturity, and poor weed competition. High seeding rates may result in thick stands with higher disease incidence, overcrowding, and less branching, especially in years of low precipitation. If possible, place seed into moisture; however, do not seed safflower deeper than 2 inches. Usually uniform emergence resulting in better stands is obtained with shallow seeding. Seeding into dry soil and allowing spring rains to recharge this germination zone is preferred to deep planting into moist soil.

Safflower is usually planted in 6-to 7-inch row spacing. Row spacings greater than 14 inches increase air movement and penetration of sunlight into the crop canopy. This may reduce leaf disease incidence but can favor weed competition, delay maturity, and decrease branching and seed oil content. Narrow rows are best for competing with weeds and usually result in more uniform stands that mature earlier.

Safflower has no official test weight. The seed is about the same size as barley and weighs approximately 38 pounds per bushel. Drill settings for seeding safflower often correspond to settings for similar seeding rates of barley. The following information rule can help calibrate your drill prior to planting: a 20-pound-per-acre seeding rate planting in 12, 10, 8 and 6-inch rows would require six, five, four and three seeds per linear foot of row, respectively. Seedling losses are often as high as 40-50 percent. A rate of 20 pounds per acre is sufficient if seedling losses are minimal, but growers should plant 25-30 pounds per acre to allow for the higher losses. Adequate stand establishment is extremely important for maximum production with minimum weed and early maturity. If soil crusting occurs, running empty disk drills across the field or a light harrowing can improve seedling emergence. Care must be taken not to uproot, cover with soil, or damage seedlings.

Fertilizer Requirements

The amount of commercial fertilizer required for safflower production will depend on yield goal, where safflower is placed in a rotation, and other crops included in the rotation. Safflower will root deeper than small grains. This allows the plant to utilize nutrients that may be positionally unavailable to small grains and flax. Conversely, if safflower follows a crop with a similar rooting depth (i.e. corn, sunflowers), more fertilizer may need to be applied than if safflower follows wheat, barley, oats, flax, or fallow in a rotation. Nitrogen is most often the limiting nutrient on non-fallow land. Phosphorus can be limiting on both fallow and non-fallow land.

Yield is influenced by local climate, soil type, and management (timeliness of planting, plant population, variety, weed control, etc.). The NDSU soil test data and recommendations (Circular SF-727, Fertilizing Safflower) are based on a sampling depth of 2 feet. Because safflower roots penetrate to depths of more than 4 feet, sampling to depths greater than 2 feet should increase the accuracy of fertilizer recommendations. Yield goals should be realistic, based on long time averages and management ability of the grower. Yields have ranged from 500 pounds per acre when moisture was limiting or weed and/or disease pressures were high, to more than 2500 pounds per acre under conditions relatively free of weeds, diseases, and insects and when adequate moisture and fertility were available. A general rule of thumb is that for every 100 pounds of seed produced, safflower plants will require 5 pounds of nitrogen applied and in the soil. A 1000 pounds per acre yield goal then requires 50 pounds of total N.

The method of nitrogen application will depend on the nitrogen source used. Anhydrous ammonia should be applied 4-6 inches beneath the soil surface. Broadcast-applied urea and other dry or liquid nitrogen fertilizer products should be worked into the soil shortly after application. Drill row application should never exceed 15 pounds of actual nitrogen per acre, since seedling injury may occur if this level is exceeded. Urea should never be applied with the seed. Fall application of nitrogen on well drained sandy soils is not recommended because of possible leaching.

Safflower grown on soils with low phosphorus and/or potassium tests depends heavily on applied fertilizer. Because of position availability, banding or drill applying phosphorus is more efficient than broadcasting. Up to 35 pounds per acre of phosphate can be safely drill applied. If the amount of potassium required by soil test exceeds 10 pounds per acre, then the potassium should be broadcast. Safflower has not consistently responded to phosphorus and potassium application unless the soil tests in the low range.

Weed Control

Safflower is a poor competitor with weeds, so weed competition is frequently a serious production problem. Early season crop growth is slow, allowing weeds to become established before the plant can shade the soil surface. Do not attempt to grow safflower without a good weed control program.

The following herbicides are cleared for weed control in safflower: EPTC (Eptam), trifluralin (various brand names) and metolachlor (Dual II). See current NDSU Extension Circular W-253, North Dakota Weed Control Guide, for specific recommendations. In recent years, herbicides have been used extensively but have not been totally effective in controlling broadleaf weeds. Kochia, Russian thistle and wild mustard are the most difficult weeds to control. Perennials like Canada thistle and perennial sowthistle can be serious problems. Safflower should not be grown on fields with heavy infestations of perennial weeds.

If weeds emerge before the safflower, harrowing with a light spike tooth or light coil spring harrow may control some weeds, but damage to the emerging safflower can occur and some plants may be buried. When safflower is planted in wide rows, shallow cultivation between the rows will kill most small weeds.

Disease Problems

Diseases have been a problem in years of above normal rainfall with extended periods of high humidity. The two most serious diseases under these conditions are Alternaria leaf spot (*Alternaria carthami*) and Pseudomonas bacterial blight (*Pseudomonas syringae*). Alternaria is characterized by the development of large brown, somewhat irregular spots on leaves and flower bracts. The resultant loss of photosynthetic tissue reduces yield. Planting disease-free and appropriately fungicide treated seed is recommended. Growers should select varieties carefully since some are more susceptible to Alternaria leaf spot than others.

Bacterial blight has symptoms very similar to Alternaria leaf spot and usually appears after heavy rains. Symptoms include reddish brown lesions that turn white with age. These lesions usually have yellow green margins. Both disease organisms can be found on the same plant. Control practices for bacterial blight are the same as for Alternaria leaf spot (variety selection and disease free seed).

Safflower rust (*Puccinia carthami*) is rarely a problem. The seed borne spores of safflower rust are readily controlled by seed treatment. The planting of clean, disease-free seed and the use of seed treatments are recommended practices. Infection may occur from disease spores overwintering on safflower residue. Proper crop rotation and field selection are important.

Other diseases that could cause reduction in yield but have not been a problem in recent years in North Dakota are: Sclerotinia root rot or head rot (infection from ascospores), Botrytis head rot (needs wet conditions at flowering and may be a serious

disease in higher rainfall areas or under irrigation), Phytophthora root rot (usually occurs under water logged soil), Verticillium wilt (cold, wet weather after planting is needed), Fusarium wilt (needs cool, wet weather in early season) and Pythium root rot.

Control of these diseases is best obtained by planting disease-free seed, treating the seed with proper fungicides, and crop rotation. Safflower should never follow safflower, sunflower, dry bean, soybean, mustard, canola/rapeseed or lentils in a rotation. A four-year rotation should separate these susceptible crops. When possible, select varieties with disease tolerance. Most of the newer varieties have some tolerance to the major diseases.

Recommended seed treatments are listed in the most current NDSU Extension Circular PP-622, Field Crop Fungicide Guide, available at your county extension office. No seed treatment provides protection against bacterial blight.

Insect Problems

Safflower has relatively few insect pests that cause economic damage. Grasshoppers are a potential problem. Insecticides are available and producers should consult the NDSU Extension Circular 1143, Insect Control Guide, available at local extension offices, for latest recommendations. Wireworms can reduce stands but can be controlled with Lindane either as a planter box treatment or as a combination with seed treatment fungicides.

Other insects that could be a potential problem include cutworm, seed corn maggot, leafhopper, and armyworms. Eastern flower thrips, lygus bug, and onion thrips may feed on safflower and can occasionally reach populations high enough to warrant control measures. If significant populations of these insects occur, contact your county extension office for recommended control measures.

Harvesting and Storage

Safflower is physiologically mature about one month after flowering and ready to harvest when most of the leaves have turned brown and only a tint of green remains on the bracts of the latest flowering heads. Plants are dry but not brittle and seeds should rub freely from the heads. Safflower is very spiny at maturity, so use caution when hand threshing seeds from heads. Seed shattering is usually not a problem, although safflower should be harvested as soon as it is mature to minimize the danger of shattering. Excessive rain and high humidity after physiological maturity of the seed may cause sprouting in the head. Bird damage to mature standing fields has rarely been a problem but may develop when fields adjoin a bird sanctuary. Most safflower grown in North Dakota is ready to harvest in early to late September, depending on weather conditions during the growing season.

Safflower is usually directly harvested with a small-grain combine. Swathing should be avoided unless the presence of green weeds prevents straight combining. To prevent cracking of the seed, the combine cylinder speed should not exceed a peripheral speed of 3000 feet per minute. This will be about 500 rpm for a 22-inch cylinder. Suggested concave clearance is 5/8 inch at the front and 1/2 inch at the back. Shaker speeds greater than those used for small grains are required to prevent plant residue from plugging the machine. Air should be adjusted to remove most of the empty or unfilled seeds. During the harvest operation, a white fuzz from the seed heads is abundant in the air and may clog combine radiators and air intakes, causing the combine to overheat. Small-meshed screen enclosures over these cooling mechanisms should minimize this problem, or blowing out radiators with air once or twice daily may be necessary. Accumulations of this fuzz can be a fire hazard as well as an annoyance to the combine operator.

For safe long-term storage, threshed seed should not exceed 8 percent moisture. Drying the seed can be accomplished following the same precautions and procedures as for sunflower. Drying temperatures should not exceed 110 F to ensure high oil yield and no seed damage. Harvesting at 12 percent seed moisture and drying with aeration if air temperature is warm and humidity is low results in the least harvest losses.

Marketing

Historically, nearly all safflower produced in North Dakota, Montana and South Dakota is grown and sold under contract. Contracts should be negotiated prior to spring planting. Basically the contract will promise to buy at a set price your total production from a specific number of acres agreed to by the grower. Price per ton may vary depending on seed oil content and/or test weight. Contracts should include price per unit, payment provision, acreage to be grown, storage payments and provisions, premiums and discounts for oil content or test weight as well as moisture content and dockage, final delivery point and freight allowances, and an "Act of God" clause in case of crop disaster. Contracts are still recommended as a safe way to market safflower seed.

Varieties

Almost all commercially available safflower varieties have been tested at western North Dakota Research Centers. See the current NDSU Extension Circular A-1105, North Dakota Alternative Crop Variety Performance, for agronomic performance information. Agronomists at the respective branch stations or county agents can be consulted for variety recommendations. A description of the most popular commercial safflower varieties and agronomic traits are shown in Tables 1, 2, and 3. Often the grower will be limited to growing varieties that are contracted by the buyer and contractor. Finch, Montola 2000, and S-208 are currently the preferred varieties for the bird seed market because they have a pure white seed (normal hull) without any striping. Oleic and linoleic safflower varieties should not be mixed or grown within one mile of each other.

Table 1. Safflower Variety Descriptions

Variety	Origin ¹	Hull Type ²	Oil Type ³	Dryland Yield	Irrigated Yield	TWT	Relative Ratings ⁴			Tolerance ⁵	
							Oil	Height	Maturity	Alt.	BB
Centennial	MT,ND	STP	Lino	m.good	v.good	med.	v.good	m.tall	med.	MT	MT
Finch	MT,ND	N	Lino	good	good	v.high	fair	med.	m.early	MS	T
Morlin	MT,ND	STP	High Lino	v.good	good	med.	good	m.tall	m.late	T	T
S-208	ST	N	Lino	fair	good	med.	good	med.	m.early	S	VS
S-541	ST	STP	Lino	fair	v.good	m.high	v.good	m.tall	med.	MS	MS
Montola 2000	MT,ND	N	Oleic	m.good	good	med.	good	short	early	MS	MS
Montola 2001	MT,ND	STP	Oleic	v.good	m.good	med.	good	med.	med.	MT	MT
S-317	ST	STP	Oleic	m.good	good	med.	good	m.tall	med.	MS	S
S-518	ST	STP	Oleic	fair	good	med.	good	m.tall	m.late	MS	S

¹ ST = SeedTec International, MT = Montana, ND = North Dakota

² STP = striped (usually purple and white), N = normal or white

³ Lino = linoleic, Oleic = oleic

⁴ Relative ratings of Yield, Test Weight and Oil will vary under conditions of moderate-severe disease infestation.

⁵ Alt = alternaria leaf spot disease, BB = bacterial blight, S = susceptible, MS = moderately susceptible MT = moderately tolerant, T = tolerant

Table 2. Safflower Agronomic Traits (average across six locations¹)

Variety	Days to First Flower	Plant Height (inches)	Test Weight (lb/bu)	Oil (%)
Centennial	87.8	26.8	36.9	37.6
Finch	84.9	26.6	41.0	33.3
Montola 2000	84.8	22.1	35.9	35.5
Morlin	88.7	25.4	37.3	35.8
S-541	86.6	26.5	37.4	37.9

¹ Locations where data are not included: Days to first flower, plant height, and oil = McKenzie County and Mountrail County (2 sites).

Table 3. Irrigated Safflower Agronomic Traits (Sidney, MT)

Variety	Days to First Bloom	Plant Height	Test Weight	Oil
	from July 1	Inches	Lbs/Bu	%
Centennial	27.5	25.5	36.8	39.9
Finch	25.0	28.5	40.6	36.1
Montola 2001	25.0	25.5	36.8	39.1
Montola 2000	24.5	23.0	36.7	38.8
Morlin	27.0	26.5	38.4	38.5
S-541	26.5	27.0	38.2	39.6
S-317	27.5	28.0	36.8	39.0



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