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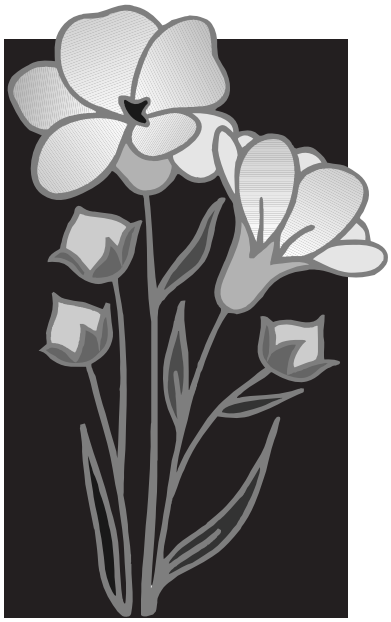

Flax Production in North Dakota

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History and Use

Flax (*Linum usitatissimum*) production goes back to ancient history. Flax remnants were found in Stone Age dwellings in Switzerland, and ancient Egyptians made fine linens from flax fiber. Flax production moved west across the northern United States and Canada during the 1800s. As settlers moved west, flax was one of the crops produced. North Dakota farmers have grown flax since sod first was broken.

Producers grow two types of flax: seed flax for the oil in its seed and fiber flax for the fiber in its stem. Today producers in the upper Midwest and the Prairie Provinces of Canada grow seed flax. North Dakota is the leading producer of flax for oil and food use in the United States. Flax seed is crushed to produce linseed oil and linseed meal. Linseed oil has many industrial uses; linseed meal is used for livestock feed. The fiber in seed flax stems is used to make fine paper and as tow or padding in upholstered furniture. Cigarette paper is a major flax paper product.

Human consumption of flax seed is increasing rapidly for its high dietary fiber, its omega-3 oils and anti-carcinogenic lignans. Flax seed oil is used as a vegetable oil by some consumers and processors say its use is doubling annually. Whole, (preferably) ground flax seed is consumed mostly in bakery products. Hens fed flax seed produce "omega eggs," which are sold in the U.S. and Canada for their high omega-3 oil content. Much flax seed meal also is

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fed to pets and other animals. Research is being conducted to determine the health benefits of human consumption of flax seed products.

Fiber flax is grown in Europe and Asia. Its fiber is used to make fine linen cloth. Fiber flax varieties are very tall with few branches and low seed production. Seed flax is short, multiple branched and selected for high seed production.

Growth and Development

Flax is an annual plant that has one main stem. At low plant populations, branching is seen at the base similar to tillers in a cereal grain. The stems terminate in a multibranched inflorescence that bears blue to white flowers. Flax grows to a height of 24 to 36 inches. The plant has a tap root that may penetrate to 40 inches if growing conditions are favorable. It requires a 50-day vegetative period, 25-day flowering period and about 35 days to mature. In years when moisture is available, the maturation period may extend until a hard frost kills the crop. In a wet fall, new flowers often are observed until frost.

Flax is a self-pollinated crop. Seed is produced in a boll or capsule. A complete boll can have 10 seeds, but most bolls will have fewer, averaging around six seeds. Seeds can be brown, golden or yellow. The seed is covered with a mucilaginous coating. This coating becomes sticky when wet. During a wet harvest, this coating may discolor, giving the seed a weathered appearance and a reduced test weight.

Growing Flax

Flax usually is sown on the same type of land that grows wheat and barley. Poorly drained soils, soils subject to drought and erosion, and soils high in soluble salts should be avoided. Flax should fit into many small-grain rotations.

For optimum yields and disease control, do not plant flax more often than one in three years in any rotation. Also, try to avoid planting flax after potato, canola and sugar beet.

Select a variety adapted to your area. Variety descriptions and recent yield performance can be obtained in NDSU Extension publication A-1049, "North Dakota Barley, Oat, Rye and Flax Variety Trial Results and Selection Guide," available at your county Extension office or on the NDSU Extension Web site. Consider planting certified seed. Certified seed is tested to ensure minimal weed content, high genetic purity and good seed viability. Certified seed consistently outyields bin run seed. All recent varieties have an adequate oil yield and oil quality (iodine number) to meet industry specifications.

Treating flax seed with a recommended fungicide is necessary. Seed treatment reduces seed decay and seedling blights and can increase stand significantly. A thicker and more uniform stand produces higher yields. Yellow-seeded varieties are more susceptible to seed decay than brown varieties. Treated seed stored for long periods needs to be retested for germination before use.

Fertilizing Flax

Flax can be grown under fertility levels similar to small grains. Use soil testing as a guide for applying fertilizer whenever possible. Recommendations for fertilizer use in flax are presented in NDSU Extension publication SF-717, "Fertilizing Flax." Zinc deficiency has been reported on flax in North Dakota, so information on zinc levels should be requested when soil testing. If soil zinc levels (DTPA extract) are less than 1 part per million (ppm), application of zinc is recommended. Recently the recommendation for phosphorus application for flax production was removed. Research data suggested flax had no yield response to added phosphorous fertilizer.

Flax nutrient recommendations based on soil tests (N and K).

Yield goal	Soil N plus fertilizer N required	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre (2 ft.)	K_2O, lb/acre				
20	60	38	27	16	5	0
30	80	58	41	24	7	0
40	80	77	54	32	10	0
50	80	96	68	40	12	0

Nitrogen recommendation = 3 YG - STN – PCC, with limit of 80 lb/N.

N is limited to 80 lb/a due to the risk of lodging. If environment is favorable for higher yield, higher N release from organic matter will provide the additional N needed in most situations.

Phosphorus application is not necessary for flax. Phosphorus can be applied, but no yield increase should be expected regardless of soil test level.

Potassium recommendation = (2.200-0.014 STK)YG

Source: NDSU Extension publication SF-717, "Fertilizing Flax"

Seeding Flax

Flax should be sown into firm, moist soil. A well-prepared, firm seedbed will ensure sowing at the proper depth. This, in turn, will result in uniform germination and rapid, even emergence. A planting depth of 0.75 to 1.5 inches is recommended. Press drill packer wheels do a satisfactory job of firming the soil after planting. If other types of planters are used, producers need to use special efforts, such as a soil packer behind the drill or harrowing prior to planting to firm the seedbed. Avoid deep seeding because delayed emergence weakens seedlings, and weak seedlings are more likely to die. When preplant-incorporated herbicides are used, shallow planting is a must to reduce stress on emerging flax seedlings. Flax seedlings are less able to force their way through a soil crust than wheat seedlings.

A stand of 70 plants per square foot is desired. However, if uniform, stands of 30 to 40 plants per square foot may provide a satisfactory yield. As stands drop below 30 plants per square foot, weed infestation and delayed maturity are added problems.

Seeding rates of 25 to 45 pounds per acre are common. In general, use lower rates (25 to 35 pounds) in western North Dakota and higher rates (35 to 45 pounds) in the east. Seed size varies among varieties, which also should be considered. Yellow-seeded varieties may require higher seeding rates because of lower seedling vigor. If untreated seed is used, then higher rates are necessary.

Early seeded flax generally produces the highest yields. Early seeding normally occurs in late April for all of the state except the northeast, where early May seeding is possible. Frost seldom kills flax seedlings. Seedling plants just emerging (breaking ground) are the most susceptible to injury but can withstand temperatures down to 28 F for a few hours. After the seedlings have a second leaf, they can withstand temperatures into the low 20 F range. Deferred sowing may aid in weed control and labor or equipment utilization, but almost always results in lower yields. Nonuniform maturity and ripening is a problem in late-seeded fields and additional management at harvest often is needed. Flax varieties vary in response to date of planting. Full-season varieties should be planted early.

North Dakota flax variety descriptions.

Variety[1]	Origin	Year Released	Relative Maturity[2]	Seed Color	Plant Height	Wilt	Relative Yield
NorLin	Can.	1982	early	brown	med.	MS	good
AC-Watson	Can.	1996	early	brown	short	MR	v. good
CDC-Valour	Can.	1996	early	brown	short	MR	v. good
Linton	ND	1985	early	brown	med.	R	v. good
Prompt	SD	1988	early	brown	med.	MR	good
Hanley	Can.	2002	mid/early	brown	med.	R	v. good
AC-Emerson	Can.	1994	mid.	brown	med.	VR	v. good
CDC-Normandy	Can.	1995	mid.	brown	short	MR	v. good
Cathay	ND	1998	mid.	brown	med.	MR	v. good
Pembina	ND	1998	mid.	brown	med.	MR	v. good
Carter	ND	2004	mid.	yellow	med.	R	v. good
Neche	ND	1988	mid.	brown	med.	R	good
Omega	ND	1989	mid.	yellow	med.	MS	v. good
Rahab 94	SD	1994	mid.	brown	med.	MR	good
CDC Arras	Can.	1999	mid.	brown	med.	MR	v. good
CDC Bethume	Can.	1999	mid/late	brown	med. tall	MR	v. good
AC Carnduff	Can.	1998	mid/late	brown	med. tall	MR	v. good
CDC Mons	Can.	2003	mid/late	brown	med.	MR	v. good
Taurus	Can.	2003	mid/late	brown	med.	MR	v. good
Flanders	Can.	1989	late	brown	med.	MS	good
Webster	SD	1998	late	brown	tall	MR	v. good
McDuff	Can.	1993	late	brown	med. tall	MR	v. good
AC Linora	Can.	1993	late	brown	tall	R	v. good
Selby	SD	2000	late	brown	tall	MR	good
York	ND	2002	late	brown	med.	R	v. good
Nekoma	ND	2002	late	brown	med.	MR	v. good
Lightning	Can.	2002	late	brown	med. tall	R	v. good

[1] All varieties have resistance to prevalent races of rust; all have good oil yield and oil quality.

[2] Varieties listed in order of maturity.

Pest Control

Weed control

Flax is less competitive with weeds than small grains and should be grown on relatively weed-free fields. Control weeds in and following harvest of the preceding crop. Postharvest tillage of small-grain stubble will prevent weed seed production, suppress perennial weeds and encourage annual weed seed germination prior to freeze-up. Flax should be seeded directly or with shallow spring tillage in fields. Deep tillage on such fields could bring dormant seeds to the surface and increase weed problems.

For weedy fields, moldboard plow the soil to bury the weed seeds, reducing the weed infestation the following crop season. Moldboard plowing can reduce infestations of small-seeded weeds, such as foxtails and kochia, which have short seed survival. Delayed seeding of flax with tillage prior to seeding will control wild oat and reduce infestations of other early germinating weeds. However, delayed seeding generally reduces flax yields. Early maturing flax varieties should be used with late seeding.

Weed control is needed by flax emergence to reduce yield losses since flax is a poor competitor with weeds. Soil-applied herbicides reduce weed emergence and minimize early weed competition to maximize flax yields. POST herbicides applied soon after weed emergence to small weeds and flax usually give better control and allow more time for flax recovery from possible herbicide injury than they do to larger weeds and flax.

Post-applied grass herbicides

Assure II, Targa, Poast, Clethodim and Select Max are all grass-controlling herbicides that are labeled to control grasses in flax.

See table on page 6 for rates, time of application and remarks. See individual labels for mixing guidelines with broadleaf herbicides, such as bromoxynil and MCPA ester formulations.

For more information on all herbicides labeled for weed control use in flax, refer to the "North Dakota Weed Control Guide," NDSU publication W-253 (current year). Always read and follow the label in the use of all pesticides.

Insects

Insect problems and yield loss may occur any year. A program of timely field monitoring should be followed. Know the economic threshold levels for the various insects and apply control measures promptly. The following insects can be problematic in flax:

Grasshoppers – Grasshoppers are a problem, especially near or at harvest. Flying adults invade from neighboring fields. Damage is caused by chewing through the succulent portion of the small stems below the bolls, with bolls dropping to the ground. Seedling feeding may be a problem in late-seeded fields.

Cutworms and armyworms – Larvae of one or more cutworm species are known to cut and consume seedlings at the soil level. Damage is often severe by the time the infestation is identified. Armyworm larvae feed on foliage in midseason.

Aster leafhopper – Leafhoppers feed on the plant juices. This insect infects the plant with the aster yellow mycoplasm when feeding. The aster yellow disease also is observed on canola, sunflower and several broadleaf weeds.

Aphids – Aphid populations can increase rapidly and have been observed on flax. Their numbers most years are not high enough to cause economic loss.

Wireworm – This insect, while mostly a pest of cereal grains, occasionally can cause reduced stands in flax.

For information on insect control, contact your local county Extension office for information on approved control practices, available labeled insecticides and economic thresholds for the major insects.

FLAX

Herbicide	Product/A (lb ai/A)	Weeds	When to Apply	Remarks
Glyphosate	**1 to 3 pt of a 3 lb ae/gal conc.** (0.38 to 1.125 ae)	Emerged grass and broadleaf weeds	Preplant or anytime prior to crop emergence	lb ae/gal / lb ai/gal / 0.38 ae / 0.57 ae / 0.75 ae / 1.125ae 3 / 4 = 16 fl oz / 24 fl oz / 32 fl oz / 48 fl oz 4/4.17 / 5.4/5.1 = 12 fl oz / 18 fl oz / 24 fl oz / 36 fl oz 4.5 / 5.5 = 11 fl oz / 16 fl oz / 22 fl oz / 32 fl oz 5 / 6.1 = 10 fl oz / 5 fl oz / 20 fl oz / 30 fl oz Nonselective, nonresidual, translocated, foliar herbicide. Apply with AMS fertilizer.
Aim (carfentrazone)	**1/2 to 1 fl oz EW** (0.128 to 0.256 oz)	Small broadleaf weeds		Contact herbicide; thorough coverage required. Apply with NIS at 0.25% v/v to small weeds.
Trifluralin	**1 to 2 pt** **5 to 10 lb 10G** (0.5 to 1)	Grass and some broadleaf weeds	PPI Fall	Adjust rate for soil texture. Deep incorporate within 24 hours after application. Keep spring tillage depth shallower than fall and plant shallow.
Bromoxynil	**1 pt** (0.25)	Small broadleaf weeds	Flax: 2 to 8 inches tall	Poor wild mustard control. Good buckwheat control. Flax injury is possible.
MCPA	**0.5 pt of a 4 lb/gal conc.** (0.25)			Use MCPA ester on hard-to-kill weeds. Early application is less injurious to flax.
Bromoxynil + MCPA (Premix)	**0.9 pt of a 4 lb/gal premix or 0.71 pt/11.4 fl oz of 5 lb/gal premix.** (0.23 + 0.23)			Apply to small weeds prior to bud stage of flax. Risk of flax injury. Commercial mixtures are available.
Commando M **Curtail M** (clopyralid+MCPA)	**1.33 to 1.75 pt** (1.1 to 1.5 oz + 6.25 to 8.25 oz)	Broadleaf weeds, including Canada thistle and per. sowthistle	POST. Flax: 2 to 6 inches tall Canada thistle: 4 to 6 inches tall	Apply after most thistle shoots have emerged. Allow a 72-day PHI. Follow rotational crop interval and other precautions on product label.
Assure II **Targa** (quizalofop)	**8 to 10 fl oz** (0.88 to 1.1 oz)	Annual grasses and quack grass	POST. Flax: Refer to PHI	Apply with oil adjuvant at 1% v/v but not less than 1 pt/A. Oil adjuvant at more than 1 qt/A is not needed. See Select Max label for detailed adjuvant recommendations. May be tank-mixed with bromoxynil or MCPA ester for broad-spectrum weed control. Refer to soybean section, label or narrative for tank-mix options, possible grass antagonism with broadleaf herbicides and avoiding reduced grass control. Allow a 75-day PHI for Poast and 60-day PHI for clethodim. Refer to label for PHI of Assure II/Targa. Clethodim may injure flax when applied during bloom.
Poast (sethoxydim)	**0.5 to 1.5 pt** (0.1 to 0.3)	Annual grasses		
Clethodim	**4 to 8 fl oz** (1 to 1.25 oz)	Annual grasses and quack grass		
Select Max (clethodim)	**9 to 16 fl oz** (1.125 to 2 oz)			

Preharvest Application

Credit Extra **Durango Glyphosate 41%** **Glyphos** **Glyphomax Plus** **Gly Star Plus** **RT 3 or Master II** **Touchdown CT** (glyphosate)	**2 pt of a 3 lb ae/gal conc. or 22 fl oz of a 4.5 lb ae/gal conc.** (0.75 ae) **See Remarks.**	Emerged grass and broadleaf weeds including Canada thistle and perennial sowthistle.	Preharvest. Flax: Physiologically mature. Seed contains 30% or less moisture.	lb ae/gal / lb ai/gal / 0.38 ae / 0.57 ae / 0.75 ae / 1.125ae 3 / 4 = 16 fl oz / 24 fl oz / 32 fl oz / 48 fl oz 4/4.17 / 5.4/5.1 = 12 fl oz / 18 fl oz / 24 fl oz / 36 fl oz 4.5 / 5.5 = 11 fl oz / 16 fl oz / 22 fl oz / 32 fl oz 5 / 6.1 = 10 fl oz / 15 fl oz / 20 fl oz / 30 fl oz Allow a 7-day PHI. **Do not apply to flax grown for seed because reduced germination/vigor may occur.**
Drexel Defol (sodium chlorate)	**1 gal of a 6 lb/gal conc.**	Desiccant.	70 to 80% of the bolls should be brown.	Contact herbicides; thorough coverage required. Do not graze or feed treated straw. Allow a 7-day PHI.

Diseases

Losses from diseases largely are responsible for the concept that flax is a risky crop and is "hard on the land." In recent years, due to the widespread use of disease-resistant varieties, disease losses have been smaller in flax than in most other annual crops. To guard against flax diseases, grow resistant varieties, use seed treatments, plant early, use sound disease-free seed and avoid planting flax after flax in the rotation.

Contact your county Extension office for recommended disease-control measures. Consult NDSU Extension publication PP-533, "Symptoms of and Controls of Crop Diseases."

The diseases most often associated with flax production are:

Disease	Control Practice
Flax wilt	resistant variety
Flax rust	resistant variety
Pasmo	crop rotation
Aster yellows	early seeding
Damping off-seedling blight	clean seed
Root rot	clean seed, seed treatment, rotation

Heat canker is a physiological reaction of the young seedling to high temperature at the soil surface. Thin stands on dark soils are most susceptible. If plants are injured when small, the plants fall over and die. When plants are larger, the outer stem tissue responds by producing additional cork tissue at the damage site. This wound tissue is often brittle and plants may break over at the soil line from strong wind. Early planting and surface residues help reduce heat canker incidence most years.

Harvesting and Storage

Flax maturity can be judged by the color of the bolls. Flax should be harvested when 90 percent of the bolls turn brown. The stems may remain green after the bolls are ready to harvest. Flax with green stems is the most difficult of all grains to cut. Sharp, well-adjusted cutter bars are essential. Flax can be straight-combined if maturity is uniform and green weeds are not a problem. If flax is swathed and pickup combined later, a tall stubble is desired. Using swath rollers can help settle the swaths into the stubble to reduce wind damage and aid pickup combining. Manufacturers' recommendations should be followed to reduce seed damage during combining. Some combines have special rollers ahead of the cylinder to fracture the flax boll. The seed coat of flax is damaged or broken easily, so proper adjustments are necessary. Yellow-seeded varieties are more susceptible to seed damage because of their thinner seed coat.

Flax seed is safe to store at 10 percent moisture short term and at 8 percent long term. Higher moisture will result in heating and mold formation. Flax seed often comes from the combine with large amounts of green weed seed dockage. A good management practice is to remove green dockage before storage.

Flax is more difficult to manage in storage than cereal grains. Systematic monitoring is recommended. Flax seed has a low angle of repose. Producers also must have tight storage bins. Even small holes and cracks will result in bin leakage. Enter flax bins with caution. Flax seed in storage flows easily and supports limited weight. Lives have been lost by people falling into seed flax bins and becoming engulfed and dieing from suffocation. Stored grain insects are not a general problem in short-time storage. If flax seed is stored for a year or more, then monitoring for the hard-bodied grain weevils is advised.

Seed Flax Straw

Combines should be equipped with straw choppers and spreaders to redistribute the straw evenly. Burning flax residue once was a common practice. This no longer is recommended. If industrial markets develop for seed flax straw, other methods of collecting straw and transporting it from the field will be identified. Green flax straw may have a prussic acid problem if used as livestock feed. **Use caution in feeding flax straw or grazing, especially immediately after a frost.**

For more information on this and other topics, see: www.ag.ndsu.edu

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