Western Region

Sustainable Agriculture Research and Extension

Alternative Crops for Dryland Agriculture in the Intermountain Pacific Northwest

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GROWER EXPERIENCES WITH FLAX AND LINOLA IN EASTERN WASHINGTON, 1997–2000

By Norm Herdrich, Agricultural Writer

The information for this bulletin was gathered from a seminar held in Washington State in February 2000. Speakers included Chad Shelton, Western Farm Service, Spokane, WA; and David McAndrew, Morden Cereal Research Center, Manitoba, Canada.

Flax belongs to the genus *Linus*. It is a member of the Linaceae family. Cultivated flax belongs to the species *L. usitatissimum*. Two general types of flax are grown for commercial production—oil linseed and fiber to manufacture linen. In general, varieties grown for fiber have longer straw with fewer branches than the oilseed varieties. Fiber flax produces a higher yield of high-quality fiber, but a lower seed yield with lower oil content than do the oilseed varieties. Currently, no commercial production of flax for fiber exists in North America, although some interest in using flax fiber to manufacture paper has been expressed. Flax is used to produce fine bond papers and cigarette papers. The paper used to produce U.S. currency does contain some flax fibers.

Canada, Argentina, China, India, and the Commonwealth of Independent States (the former Soviet Union) dominate the world flax trade. Virtually all flaxseed is consumed in the country of origin, with the exception of Canada and Argentina. Canada produces about 2 million acres, and exports 95% of the crop, according to David McAndrew, a soil scientist working specifically with alternate crops for production agriculture at the Morden Cereal Research Center in southern Manitoba. According to McAndrew, North Dakota is the only state that grows significant flax acreage—up to 50,000 acres in 1999.

Fiber flax, or linen flax, also produces seeds that can be harvested for linseed oil. Linen flaxseed has about 30% less oil content than linseed flax, yet its fiber (fiber or linen flax) is more desirable than the linseed flax fiber for making linen. The shorter linseed flax straw is used in paper production.

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Linola, a recent development in the flax industry by the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, has the same relationship to flax as Canola has to rapeseed. Developed from plants that produce oils used for industrial purposes, both Linola and flax produce edible oils.

The main difference between flax and Linola is the fatty acid composition of the oil. Linola oil is much lower in linolenic acid than linseed oil from standard flax varieties. High levels of linolenic acid provide linseed oil the fast-drying characteristics important in industrial applications. Linola oil and sunflower oil are very similar in quality.

Although linseed oil is edible, the high levels of linolenic acid cause rancidity, which is an undesirable trait in an edible oil. Compared with other vegetable oils, Linola oil is low in saturated fats and high in polyunsaturated fats.

Linola seeds are golden yellow in color, compared with flaxseeds, which are brown to dark brown. In Canada, Linola is marketed to end users based on 3% or less linolenic acid. Low linolenic flax acid content of 5% or less has been termed "solin" by representatives of the Canadian flax industry. Linola is a trademarked brand of solin. The only registered varieties of solin in Canada are Linola 947 and Linola 989.

Flax is an annual that grows to a height of 16 to 36 inches, depending on variety, plant density, soil fertility, and available moisture. The plant has one main stem. Two or more branches may develop from the base of the plant when stand density is low and soil nitrogen is high. The main stem and branches produce a multi-branched arrangement of flowers. The plant has a short, branched taproot that may extend to a depth of 49 inches or more and side branches extending up to 12 inches. The life cycle of the flax plant consists of a 45- to 60-day vegetative stage, a 16- to 26-day flowering period, and a maturation period of 30 to 40 days. Water stress, high temperatures, and diseases can shorten any of the three growth periods.

Distinguish flax varieties by the color of the flower parts, which can range from dark to light blue, white, or pale pink. The anthers and stamens of the flower are either blue or yellow. Although a period of intense flowering occurs, a few flowers may continue to appear up to maturity. During the ripening process, if soil moisture is abundant and fertility adequate, stems may remain green and new growth may occur. When this happens, plants go through a second period of intense flowering. Flowers open shortly after sunrise on clear, warm days. Petals are shed in the early afternoon. The flower parts all occur in multiples of five. If the weather turns hot during the flowering period, the plant will shut down, but it may resume flowering when the temperatures moderate.

McAndrew says flax lodges quite easily, making it very difficult to harvest and causing severe yield loss. Canadian plant breeders and researchers are studying the relationship between available moisture, plant nutrients, and lodging.

The flaxseeds grow in a boll or capsule. The seed boll has five segments, each of which produces two seeds. A complete seed set produces ten seeds; however, six to eight seeds per boll is more common. When ripe, the boll opens at the tip, and the five segments separate slightly along the margin. The bolls do not normally open far enough for the seeds to fall out.

Flaxseeds are flat, oval, and pointed at one end. A thousand seeds weigh one-quarter ounce or less. Seed color will vary from light to dark reddish brown or yellow, which includes the Linola.

The shiny seed coating becomes sticky when wet and may swell with heavy rains and high humidity because the coating absorbs moisture from the air. After the seeds have become moist, then have dried, they have a scabby appearance that reduces the grade.

PRODUCTION

Flax and Linola are the same botanical species and appear similar in the field; therefore, most flax production practices will work for Linola production as well. Both require a firm seedbed with good drainage, both can be seeded into summerfallow, and both respond well when direct-seeded into stubble, or in a minimum-till situation. Inadequate weed control significantly reduces the yield as both flax and Linola are poor competitors.

Due to strict standards regarding contamination by other oilseed crops, Canada recommends a time span of five years between growing flax and Linola in the same field. Canadian research findings have shown reduced stands when flax and Linola follow Canola or mustard because flax and Linola are sensitive to toxins associated with Canola and mustard crop residue. This problem, most evident when residue from the Canola or mustard crop is not spread adequately, can be avoided by controlling volunteer flax seedlings in the spring and using no-till to plant flax into Canola or mustard stubble.

Herbicides are available to control volunteer Canola seedlings in Linola; however, no chemical exists to control Linola or flax volunteers in a Canola crop.

PLANTING

Plant as early as possible for moderate temperatures and better moisture conditions during the bloom period and seed development to promote higher yields. The seeding date depends on the average date of the last killing frost in the spring. Flax and Linola seedlings, which have just emerged, will tolerate temperatures as low as 30˚F with no damage, and can handle 27 ˚F to 28˚F for short periods.

Fungicide treatment of flax and Linola seed reduces seed decay and seedling blight, increases plant vigor, and improves stand density by as much as 100%. Avoid long-term storage of treated seed because long-term exposure of treated flaxseed to fungicides will kill the seed embryo.

The recommended seeding rate is 30 to 40 pounds per acre. Use the higher rate if the stand may be reduced because of late seeding, heavy weed competition, or poor seedbed conditions. When grown under irrigation, use a seeding rate of 30 to 35 pounds. A seeding rate of 27 to 40 pounds per acre will produce a stand density of 30 to 50 plants per square foot. Stands of less than 30 plants per square foot may produce reduced yields. The plants do compensate for thin stands by additional branching. To discourage lodging, avoid high seeding rates on good soil with adequate moisture and fertility. Researchers with Agriculture Canada found a stand as thin as 10 plants per square foot will yield more than a reseeded crop; both because of the late reseeding date and loss of moisture to additional tillage.

The optimum seeding depth is 1 to 1 1/2 inches. Deeper seeding can result in poor emergence, weaker plants, reduced yields and delayed maturity. However, if soil conditions are dry, it may be necessary to seed as deep as 2 inches to place the seed in moist soil.

All conventional seeding equipment can be used to plant flax and Linola. Canadian scientists obtained the best seeding results by using a drill equipped with press wheels that firm the soil around the seed, improving seed-to-soil contact and promoting germination. If the drill does not have press wheels, pulling a packer behind the drill, or packing or rolling the field after seeding in a separate operation can firm the seedbed.

On soils prone to crusting following a heavy rain, emergence can be a problem if the rain falls before the crop emerges. Flax and Linola do not tolerate crusted soils. If crusting occurs, a light harrowing will allow seedlings to emerge.

DISEASES

Flax and Linola are subject to Fusarium wilt. Rotating fields is the primary method used to control this problem. Linola varieties currently available have some resistance to Fusarium wilt. Rhizoctonia root rot can be a problem for flax and Linola. Seed treatment can protect against this problem.

Seedling blight can affect flax and Linola. Seed treatment is the preferred control for seed rot and seedling blight that result from cracks in the seed coat. Another disease is flax rust. Current Linola varieties have resistance to current races of rust in North America. Pasmo, a fungal disease that affects aboveground portions of the flax and Linola plants in areas with a moist climate, should not become a problem in eastern Washington.

FERTILITY

Flax and Linola typically require about 2.7 pounds of nitrogen per bushel of grain produced. The best way to determine the amount of nitrogen needed is to test the soil. Comparable wheat and flax crops will remove similar amounts of nitrogen from the soil. Neither crop uses as much nitrogen as an equivalent Canola crop.

Nitrogen deficiency symptoms include a stunted appearance with small leaves and thin stems, yellow or pale green leaves, and older leaves at the base of the stem that drop prematurely. It may also result in premature ripening of the boll, producing small seeds and decreased oil content.

Conversely, excessive nitrogen on crops grown in marginal frost-free locations can result in decreased seed quality. Under these conditions, cutting back on the nitrogen and accepting a lower yield may be the best alternative. Limiting nitrogen to promote maturity is not recommended on early seeded crops with an adequate frost-free growing season.

The phosphate requirement for a typical flax or Linola crop is 0.075 pound per bushel of grain produced. The crop requirement for phosphorus is less than for a crop of Canola or cereal grains. However, the crop is sensitive to phosphorus, and adequate amounts of the nutrient are essential for proper growth, good yields, and timely maturation.

Broadcasting fertilizer is not recommended. Deep banding about an inch below, or an inch below and an inch to the side of the seed row is the preferred alternative. Even low rates of seed-placed fertilizer can cause seedling injury. Some Canadian Researchers recommend a low rate of phosphate, not more than 18 pounds per acre of P_2O_5, while others suggest using no fertilizer with the flaxseed.

Flax is inefficient in utilizing phosphorus in the year of application. The plant roots appear less efficient than those of Canola or cereal grains in reaching phosphate fertilizer. Because high phosphorus rates can injure the seedlings, researchers advise not placing phosphorus in the seed row. The best utilization of phosphorus occurs if the phosphorus is banded below or below and to the side of the seed row. No more than 2 inches of separation should occur between the phosphorus band and the seed row.

The potassium requirement is about 1.5 pounds per bushel of grain produced. The potassium requirement is less for flax than for Canola or cereal grains. Placing the K with the seed is not recommended because damage to the seedling K can be broadcast. If using a broadcast application, the grower may need to double the rate as compared with the rate for a banded application.

A good flax or Linola crop will require about 0.5 pound of sulfur per bushel of grain produced. This is slightly less than the amount needed for Canola, but much more than for a cereal crop. Broadcast elemental sulfur is not effective in the year of application. An alternative is a sulfate that will be available in the year of application.

Micronutrients generally are not a big concern with flax and Linola, although ground with a history of copper deficiency will benefit from additions of copper. The crop is most sensitive to iron and zinc deficiencies. A zinc deficiency will show up as slow and shortened growth of the main stem of the plant. The plant may develop a rosette appearance, and pale green leaves may eventually take on a necrotic appearance. Dieback will occur on the youngest leaves and progress to the oldest leaves. On occasion, boron, manganese, chloride, iron, and molybdenum deficiencies have been found in parts of Canada. If you suspect a deficiency, confirm it using tissue analysis.

WEED CONTROL

Two herbicides are registered for use on Linola—Buctril for broadleaf weed control and Roundup for preharvest weed management.

Materials approved for flax to control broadleaf weeds include Buctril, MCPA Poast, and the trifluralins. Roundup is used preplant to clean up fields, but McAndrew cautions problems can arise when using Roundup in no-till situations. In a low-disturbance tillage system having high amounts of residue, the Roundup can stay on top of the straw and not be deactivated.

Roundup in this situation can hurt flax seedlings up to 2 weeks after seeding. Flax is very tolerant of most weed control chemicals, but not of Roundup.

INSECT CONTROL

Flax is self-pollinating, but insect activity in a flax field will result in up to 2% outcrossing. Aphids, Bertha armyworms, cutworms and grasshoppers can be problems in Linola. Economic thresholds are three or more aphids per stem at time of full flower, or eight or more aphids per stem at the green boll stage. For Bertha armyworms, the threshold is ten or more larvae per square yard. For grasshoppers it is eight to twelve per square yard, and for cutworms, it is four to six per square yard.

The flax bollworm is a climbing cutworm that only attacks flax. The moths deposit their eggs in the open flowers, and the larvae eat the developing seed within the boll. When older, the worms leave the boll and complete development by feeding on other bolls from the outside. At this point, this pest seems to be limited to west central Saskatchewan, so it is unlikely that it would appear in eastern Washington.

In addition to the pests listed above, beet webworms, aster leafhoppers, and tarnished plant bugs occur in economically significant numbers in Canada. The damage caused by the sucking bugs is most severe in late-seeded crops.

Insect problems in stored flax are less common than in stored cereal grains. However, insects do occur in stored flax. These include the saw-toothed grain beetle, the confused flour beetle, the merchant grain beetle, and the red flour beetle. Some flax varieties are less susceptible to insect damage caused by the saw-toothed grain beetle.

HARVESTING

Do not delay the harvest of flax any longer than necessary because fall rains can cause weathering of the seed, which lowers the grade. Freezing temperatures of 25˚F to 27˚F damage immature seeds; temperatures of 23˚F to 25˚F damage leaves; and temperatures of 19˚F to 21˚F damage the stems of flax plants.

Flax and Linola can be harvested by either combining directly or by cutting the crop in swaths. The plants are fully mature when 75% of the bolls are brown. The crop is considered completely mature when 90% of the bolls are brown. If regrowth occurs, researchers say to cut the crop when the largest amount of ripe seed can be obtained. Weathering and frost can cause seed discoloration of Linola, which reduces the grade.

In Canada, cutting in swaths followed by combining has become popular. This method assures drier seed than straight combining, especially if the crop is not uniformly mature, or if weeds are present. When cutting in swaths, leave 4 to 6 inches of stubble to hold the swath off the ground. The swath may be threshed when the leaves and stems are dry enough and the seeds rattle in the boll, or where the seed has dried to the desired moisture level as indicated by a moisture meter. Although the crop is stored at 10.5% moisture or below, it can be threshed at higher moisture levels if crop-drying facilities are available. As a rule, early sown flax is easier to thresh than late sown flax because it has a better chance to mature under drier conditions.

Keep cutter bars clean and sharp when harvesting flax and Linola. Harvesting is easier when the straw is drier. Do not allow immature flax to accumulate under the knife. Frequent applications of water or kerosene will reduce gumming of the cutter bar and ledger plates.

Chemical desiccants, used to speed crop drying, do not speed the maturity of the crop, but reduce the time from maturity to harvest. A desiccant can be applied after 75% of the bolls turn brown, which is the normal time for cutting in swaths. Applying a desiccant too early reduces yields. Studies in Canada show that applying a desiccant at the 25% and 50% brown boll stages reduced yields by 10% and 5%, respectively. This was due to premature termination of some seed development. Harvest desiccated flax as soon as possible after it is ready. This will avoid boll loss and weathering of the seed. Advantages of using a desiccant include earlier harvesting, elimination of the need for cutting in swaths, less combining time, reduced machinery use, and reduction or elimination of the need to dry the crop artificially.

Combine adjustments are critical for flax and Linola. It is easy to damage the seed coat, especially if the cylinder speed is too high. Damage is also more frequent if the seed moisture content is down to 6% to 7%. According to the Canadian researchers, the front concave and cylinder spacing should be about half as wide as the setting used for wheat. This would be $^1/_8$ to $^1/_4$ or $^5/_{16}$ inch in front, and $^1/_{16}$ to $^1/_8$ inch in back. Researchers advise using the widest spacing that will remove the seeds from the seed bolls. Filler plates in the concave can help remove seed from the bolls. A cylinder speed similar to that used for wheat is often appropriate, but monitor the grain bin for damage to the crop.

Flax and Linola are considered dry at 10% moisture. However, green seeds, weed seeds, and other green plant material can cause heating and molding if levels are too high. If plants are too dry at harvest, shatter and dropping of seed bolls is a common problem. This can result in volunteer flax, which can be hard to kill. Overwintering flax can be hard to control.

RESIDUE MANAGEMENT

In concentrated flax production areas of Canada, some firms purchase baled flax straw to process the fiber into paper products. Straw for paper production is selected from fields that are mostly free of weeds. A good flax crop will produce about 1,000 pounds of fiber per acre.

If sale of the straw is not an option, chop and spread it. Spreading unchopped straw is not a good idea because the long, fibrous stems remain for several years and can cause problems with future farming operations. Chopping the straw before spreading allows the straw to decompose more quickly so it will not be a problem in later operations.

Do not feed or graze green flax straw. It contains high levels of prussic acid. The danger of prussic acid poisoning is higher if immature flax is frozen. Mature flax straw can be used for cattle feed.

MARKETING FLAX

On the processing end, except for the characteristics of the residual oil, the meal produced from Linola is the same as linseed meal, and it can be used in the same applications. Much of the meal produced in Canada is used in dairy rations.

McAndrew notes positive signs for expanded markets for flax in the future. Emerging trends identified as holding positive potential for flax as a crop include:

- Concern for the environment
- Food industry interest
- Renewed market interest for traditional uses
- Advances in mutation breeding
- Technological developments

In addition to the obvious interest in Linola, flax has been utilized in human nutrition for approximately 5,000 years. Flaxseed is used in the baking industry and in the processed food industry. Flax also is used for animal nutrition. Flaxseed meal is used frequently in dairy rations. It can be used by commercial fish farms as well.

Traditional linseed oil products (linoleum, paints, stains, and coatings) are now seen as positive in that they are biodegradable and are produced from an annually renewable resource. Improved technology has increased interest in traditional uses for linseed oil. These include sealing for concrete surfaces and paints that resist yellowing.

Advances in breeding include development of the Linola varieties. Those involved in technological developments are looking at flax fiber for particle board and several other uses, in addition to paper.

Flax was selling for about $400 per metric ton, or about 12 cents per hundredweight, in the spring of 1998. However, increased production pushed the price down to about $300 per metric ton or 8-9 cents per cwt in January of 1999, and continued going down to 5 to 6 cents per cwt in the spring of 2000. Worldwide, there is market demand for about 2.2 million metric tons of flax annually. The May 2000 futures price was $227.60 per metric ton, which equals about a $190 per metric ton farm-gate price.

When looking at cost of production, McAndrew said the seed and fertilizer costs are lower than those for wheat. Also, operating costs are slightly below costs for wheat production. He noted

Canadian producers need a yield of 31.3 bushels per acre to cover all costs. The average Canadian yield is 20 bushels per acre. Traditionally, the value of the crop does not totally cover all costs of production. Note that the Canadian bushel is 8% bigger than the U.S. bushel. Linola is a different situation. All Linola is marketed under a closed contract to United Grain Growers.

GROWER EXPERIENCE

Chad Shelton, an agronomist for Western Farm Services, has been looking at flax and Linola in his study of alternate crops. His program is now 6 years old. In 1999, he had 20 sites under both conventional and direct-seed production systems in areas ranging from 8 to 30 inches of annual precipitation. He has done more work with flax than with Linola. He noted a government loan program is available for flax, but not for Linola. Also, Linola in his plots have not yielded as well as flax. Both, however, successfully matured and set seed.

Production challenges that face potential flax producers in eastern Washington include marketing or contracting, fertility management, seeding rates, seeding dates, residue management, variety selection, residual herbicides or drift impact, and harvest dates.

Shelton says the best seeding date for flax and Linola seems to be about May 1. He said that seeding too early can lead to problems with wet conditions.

He has found the best yields are produced when 60 to 70 pounds of nitrogen are available to the plants. More than this amount boosts vegetative growth and costs more money. In plots at Genessee, Idaho, no yield differences occurred when amounts between 60 and 90 pounds of nitrogen were applied under no-till conditions.

Seeding rates under conventional tillage are 40 pounds of pure live seed per acre. This can be increased to as much as 90 pounds under certain conditions. The top yields he has seen under optimum conditions were seeded at 50 pounds per acre. For no-till situations, he says 70 pounds of seed per acre is a good place to start. The same rate can be used if seeding later into warmer soil. At the 70-pound seeding rate, Shelton said the no-till yielded better than flax grown under conventional tillage. Regarding residue management, Shelton says the straw has to be properly spread. It is very fibrous. The best practice leaves straw standing in a no-till operation.

Comparing flax and Linola, he says flax generally has outyielded Linola. However, the difference is not as great under lower rainfall situations. Varieties he has tried include Normandy, Arras, Ling Val, Norlin, Verne, and Linola 989. Normandy outyields Linola, he found. In Shelton's plots, maturity dates have ranged from September 1 to mid-October.

For weed control, Bronate is the number one product of choice, according to Shelton. Poast also can be used, but it is necessary to time the application properly to kill most of the weeds. He has seen some Fusarium wilt and aphids, although not in high enough numbers to be a problem. He also has noticed some *Pythium* damage.

Shelton says he has not seen any advantage of seed treatment over the use of the proper seeding rate. However, he suggests using seed treatment may be cheaper than increasing the seeding rate under no-till production systems.

INTERNET INFORMATION SITES FOR FLAX

Manitoba Agriculture and Food—Flax Information
http://www.gov.mb.ca/agriculture/crops/oilseeds/bgb01s00.html

Alberta Agriculture and Food—Flax Information
http://www.agric.gov.ab.ca/navigation/crops/flax/index.html

Saskatchewan Agriculture and Food—Flax Information
http://www.agr.gov.sk.ca/Crops/Oilseeds.asp

North Dakota State University—1999 Flax Variety Trials
http://www.ag.ndsu.nodak.edu/aginfo/variety/flax.htm

Flax Council of Canada
http://www.flaxcouncil.ca/flaxinde.htm

United States Department of Agriculture
http://www.usda.gov/subject/subject.html#F

FLAX CULTIVARS CURRENTLY GROWN IN CANADA

- AC Emerson
- AC Linora
- AC McDuff
- AC Watson
- AC Carnduff
- CDC Normandy
- CDC Treffid
- CDC Uder
- Flanders
- Linott
- McGregor
- NorLin
- Somme
- Vimy

Solin (Linola) Varieties

- 947
- 989
- 1084

FLAX VARIETIES TESTED IN NORTH DAKOTA IN 1999

- AC Carnduff
- AC Emerson
- AC Linora
- AC Watson
- Bison
- Cathay
- CDC Arras
- CDC Bethume
- CDC Normandy
- CDC Valour
- Flanders
- Flor
- Linott
- Linton
- McDuff
- McGregor
- Neche
- Norlin
- Norman
- Omega
- Pembina
- Prompt
- Rehab 94
- Webster

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