Flax / Linseed

Flax belongs to the genus Linum, one of 10 genera in the family Linaceae. The genus contains more than 100 annual and perennial species. Cultivated flax belongs to the species, L. usitatissimum, and its varieties are of two types: one is grown for oil and the other for fibre.

In Canada, at present, oilseed flax is the main commercially produced crop. Yet, there is a growing trend back to natural fibres for both industrial applications and textiles. This trend will only continue as pressures increase to produce materials that are recyclable or decomposable. As a result, Western Canadian businesses are realizing the value of flax straw, and are developing technologies to handle oilseed straw and produce fibre from it for industrial purposes. The extraction and processing of fibre from existing flax straw residue and the dedicated planting of fibre flax will create new production and value-adding opportunities for Western Canadian flax producers.

Crop Rotation

Flax is predominantly a stubble-sown crop in Manitoba. It is also increasing as a stubble crop in Alberta and Saskatchewan where currently more than 50% is grown on stubble. A broad spectrum of herbicides is available to control both broadleaf and grassy weeds, including volunteer cereals.

Following Canola or Mustard

Research in Saskatchewan has shown that flax sometimes does poorly after canola or mustard. This is due to toxic compounds in mature canola and mustard plants and their seedling residues. However, research in Manitoba has shown that flax yields on canola stubble were generally not affected, although small reductions occurred in some years. The problem is most evident where straw and trash from the previous canola crop have not been adequately spread on the soil surface. Canola straw should, therefore, be spread uniformly, and spring volunteer seedlings should be controlled at an early stage in order to minimize possible toxic effects. Seeding into untilled canola stubble can also minimize the problem.

The poorer performance of flax on canola stubble can also be attributed to mycorrhizae fungi which do not associate as strongly with canola roots as with flax roots. When flax is grown on canola stubble, the mycorrhizae populations tend to be lower. Mycorrhizae fungi, in their relationships to roots, will increase and improve nutrient uptake, especially phosphorus, a relatively immobile nutrient in the soil.

Following Other Crops

Flax does well after cereals or corn. It also does well after legume crops, but Rhizoctonia disease may be a problem. Flax does not do well after potatoes or sugar beets as the soil may be too loose and Rhizoctonia disease could also be a problem.

Flax does very well on alfalfa breaking as was observed by alfalfa producers in north-east Saskatchewan. Recent work at the Melfort Research Farm has demonstrated that flax will perform well on spring wheat and field pea stubble relative to canola stubble (see Table 1). Seeding flax on flax stubble will yield similar to flax on canola stubble. Seeding canola on flax stubble is preferable to flax on canola stubble.

TABLE 1

The effects of preceding crop on the yield of flax at Melfort, Saskatchewan for the period 1994-1997

Preceding Crop	Yield Index (% of spring wheat)
Spring wheat	100
Canola	88
Field pea	103

Crop rotation of at least three years between flax crops is recommended for controlling various soil-borne or stubble-borne diseases of flax (see Chapter 8 for the specific flax diseases).

OTHER CROPS FOLLOWING FLAX

Information from Manitoba and Saskatchewan has shown that crops like spring wheat will yield well on flax stubble (see Table 2).

TABLE 2

The effects of preceding crops on the yield of spring wheat for the period 1982-1993 in Manitoba.

Preceding Crop	Yield Index (% of spring wheat)
Flax	116
Field pea	111
Spring wheat	100
Canola	108

Soil Zones

Brown and Dark Brown Soil Zones

Flax is adapted to Brown and Dark Brown soils of the Prairies. With adequate weed control, the major factor influencing the yield of flax in a rotation for the Brown and Dark Brown soil zones is the availability of moisture. Because of its shallow rooting character, flax extracts 95% or more of its water from the top 71 cm (28 in.) of soil.

It appears that flax yields better on medium to heavy textured and fertile soils.
Although lack of moisture limits yields, it also allows for a high carry-over of nutrients. Therefore, it is important to fertilize according to soil test results in order to get optimum returns from the addition of fertilizer.

Flax leaves little residue on the land, thus increasing the risk of wind erosion if the land is summer-fallowed after a flax crop. Ideally, flax should be followed by a cereal in the rotation.

Black and Dark Grey/Grey Soil Zones

Flax fits into a rotation easily in the Black and Dark Grey/Grey soil zones across the Prairies, providing producers with an alternative to cereals and canola. Crop sequence studies at Melfort, Saskatchewan, have shown that flax produced higher yields on wheat and barley stubble than it did on canola, flax or oat stubble. Here, moisture is less of a yield-limiting factor than in the Brown and Dark Brown soil zones.

At Indian Head, Saskatchewan, wheat following flax showed no reduction in yield, therefore, making wheat the most acceptable crop to follow flax. Barley also performed well on flax stubble.

Minimum and zero tillage

Good post-emergent herbicides have made zero tillage viable for flax. Minimum and zero tillage practices are attractive because they provide protection from erosion, increase soil organic matter and improve moisture retention. In addition, they reduce crusting problems and sun scald, consequently improving stands of flax. Specialized seeding equipment, developed in recent years, is available for these practices.

Research at Indian Head, Saskatchewan has shown that flax is well adapted to minimum and zero tillage. In this study, minimum tillage was defined as one pre-seeding tillage operation just prior to seeding while conventional tillage involved one fall and one spring pre-seeding tillage operation. Over the 12 years of the study, flax grown with either zero or minimum tillage out-yielded conventional tillage by 13%. Water use efficiency was also greater with zero and minimum tillage, i.e. more flax seed was produced per unit of water used, even after taking into consideration that zero and minimum tillage will conserve more moisture.

Method of Seeding

Flax should be sown shallow, 2.5 to 4.0 cm (1 to 1.5 in.) deep, with a drill that places the seed at a uniform depth in rows 15 to 20 cm (6 to 8 in.) apart. Recent research has shown that up to 30 cm (12 in.) row spacing in zero tillage is acceptable. Depth of seeding trials at the University of Alberta have shown that seeding depths greater than 3 cm (1.2 in.) result in significant reductions to emergence and yield.

The most satisfactory results are achieved by using a drill equipped with press wheels which firm the soil around the seed. If a drill does not have press wheels, a soil packer may be drawn behind the drill, or the field may be packed in a separate operation.

The effect of pre-seeding tillage in terms of the type of implement, the depth of tillage and the effect of packing, either before or after seeding, has not been clearly defined. Studies at the University of Alberta have shown that deeper tillage results in poorer stand development but because this practice often leads to extensive tillering, there are not necessarily yield losses. The same effect was noticed with both pre-seeding packing and post-seeding packing. As a general rule, pre-seeding packing was beneficial even to land that also had post-seeding packing.

Dry land conditions

Seeds that are placed at a uniform shallow depth in firm, moist soil will germinate and emerge evenly and rapidly. Under dry soil conditions, it may be necessary to seed deeper than 4 cm (1.5 in.) in order to place the seeds in moist soil. However, deep seeding should be avoided whenever possible as emergence will be delayed, resulting in weak seedlings and reduced stands. Weak seedlings are more prone to injury from preplant incorporated herbicides. Furthermore, deep seeding increases the risk of a poor stand if heavy rain occurs before seedlings emerge and the soil crusts. Flax seedlings are less able to force their way through surface crusts than wheat seedlings. Harrowing, therefore, is occasionally necessary to facilitate emergence of seedlings.

Irrigated soil conditions

If irrigation is practised and the soil is moist, broadcasting the seed followed by a shallow 3 to 4 cm (1.2 to 1.5 in.) cultivation and packing has been as successful as normal drilling or air seeding.

Rate of Seeding

In general, the seeding rate should be adjusted according to size of seed, germination percentage, soil fertility, or weediness. In tests conducted in Saskatchewan and Manitoba, flax showed
little yield response to changes in seeding rate from 25 to 55 kg/ha (22 to 49 lb./ac.). A seeding rate of 30 to 45 kg/ha (27 to 40 lb./ac.) is recommended.

Higher seeding rates may be required for varieties with a yellow seedcoat (e.g. solin varieties), particularly if seed treatment is not applied. Excessively high seeding rates should be avoided where lodging may be a problem (see Photo 7).

On land under irrigation, seeding rates as high as 50 kg/ha (45 lb./ac.) can be used. However, if conditions for establishment are good, 33.6 to 39.2 kg/ha (30 to 35 lb./ac.) is adequate if weeds are controlled.

With irrigation, plant populations of 300 seedlings/m2 (30/ft.2) are adequate for optimum yield. It is extremely important to choose a variety that has a high level of resistance to lodging, since high soil moisture and fertility generally increase the potential for lodging.

Plant Stand

A seeding rate of 30 to 45 kg/ha (27 to 40 lb./ac.) results in approximately 500 to 800 seeds/m2 (50 to 80 seeds/ft.2). A seedling emergence rate of 50 to 60% is usually attained under farm conditions.

According to Manitoba Crop Insurance, yields are not significantly affected by reduction in plant stands from 400 to 300 plants/m2 (40 to 30/ft.2), but yields generally tend to drop off as stands drop below 300 plants/m2 (30/ft.2). However, even at plant stands as low as 100 plants/m2 (10/ft.2), yields were reduced only about 20%, as extensive tillering compensated for the lower stands.

Reseeding

If seedling stands are thin, a decision must be made whether to reseed or not. Flax seedling emergence is sometimes poor due to damaged seed, soil crusting, seedling diseases, adverse weather conditions, deep seeding, herbicide injury, or other reasons. Generally, yields are lower the later the seeding date, and lower because of loss of soil moisture from additional tillage. The added costs of reseeding must also be taken into account.

Early seeding

Early seeding of flax generally produces the best results, for flax is seldom damaged by light spring frosts. Plants just emerging are the most tender, but can withstand temperatures down to approximately -3°C (27°F). After the seedlings have passed the two-leaf stage and are hardened by exposure, they can withstand temperatures as low as -8°C (18°F) for a short time without damage. Unlike cereals, where the growing point of the seedling is protected under the soil surface, the growing point of the flax seedling is fully exposed above the ground and is more vulnerable to frost.

Moderate temperatures and ample soil moisture during flowering and seed development favour high yield, high oil content and high oil quality. Such conditions are more likely to occur with early seeding. As well, seeding in mid-May generally results in somewhat less lodging. High quality straw for fibre is also more likely to be obtained when flax is seeded early.

Late seeding

Late seeding of flax often results in much lower yields. Tests in Manitoba showed that compared to early seeding in May, a delay of seeding to June 1, June 10 and June 20 resulted in respective yield reductions of 7%, 29% and 52%. Late seeding also reduces oil content and seed size. Because green stems and second growth are more prevalent in a late-seeded crop, harvesting is more difficult.
However, a delay in seeding of flax may be necessary if herbicides are not used to control early starting weeds such as wild oats, or when drought or excessive moisture have delayed field work. When seeding is delayed until after June 1, only early maturing varieties are recommended because of the risk of fall frosts. Flax varieties differ in their performance under conditions of late seeding.

Water Use and Irrigation

Flax is an excellent crop for irrigated crop rotation since it is not prone to Sclerotinia stem rot which affects canola, sunflower, peas, and beans. The major effect of irrigation on flax is to promote a second or third flush of flowers and to maintain adequate moisture for plant growth until all flowers have developed seeds.

In non-restricting soils (medium-textured soils that are amenable to lots of moisture), flax develops a short, branched taproot, encompassing a rooting zone of 1 m (39 in.). Root development is nearly completed by the flowering stage. On irrigated land, flax takes approximately 70% of its water requirement from the top half of the root zone.

Over the growing season, crop water use may be as high as 41 cm (16 in.). During the seedling stage, water use will range from 1 to 3 mm/day (0.04 to 0.12 in./day), rising to a high of 7 mm/day (0.28 in./day) during the flowering stage. The critical water requirement period for flax is from flowering to just prior to seed ripening. Therefore, to maximize yield and oil content, adequate soil moisture must be maintained during that period.

Monitoring moisture use by soil moisture sensors, crop water use models, or direct measurement of crop use, is important if adequate soil moisture is to be maintained. However, the last irrigation of flax should be completed by the second week in August to ensure that the seeds ripen. Extending the last irrigation past this time will encourage continued growth in the crop, increasing the potential for frost damage and a delayed harvest. It may be necessary to irrigate in the spring for the crop to germinate. Unless soils are very heavy, a light irrigation of 15 to 20 mm (0.6 to 0.8 in.) prior to seeding is preferred to irrigation after seeding which can cause crusting and cooling of the soil.

Fertilizer Practices

Soil tests and experience should guide fertilizer practices. Nutrient levels in the soil vary greatly among regions, with soil types, cropping history and fertilizer use. Provincial fertilizer bulletins should be referred to for general recommendations regarding fertilizer requirements, rates and placement. It is generally believed that relative to other crops, flax will not perform as well on low fertility soils, even when adequate amounts of inorganic fertilizers are used.

Placement Methods
Seed-placed fertilizer

Flax is very sensitive to seed-placed fertilizer with even low rates sometimes causing seedling injury. Some provinces recommend a low rate of phosphate– not more than 20 kg/ha (18 lb./ac.) of P_2O_5 – may be seed-placed, while others recommend that no fertilizer be placed with the seed of flax. Considerable research evidence has now shown that placement of phosphate 25 mm (1 in.) to the side and 25 mm (1 in.) below the seed is an effective method to improve phosphorus nutrition in the flax plant. Nitrogen (N) should not be placed directly with the seed.

As discussed in the next section, with the advent of direct seeding using a one-pass seeding and fertilizing system, recent work has shown that adding nitrogen to the phosphorus when placed to the side and below the seed does not change the benefits of that phosphorus placement.

Other placement methods

Pre-plant deep-banding of phosphorus (P), which is often a good placement method for other crops, is not effective for flax. Broadcasting and incorporation of P fertilizer for flax is relatively ineffective, with up to a fourfold increase in application rates required to achieve the same yield result as sideband placement. The performance of P placed with the seed in the wider bands behind hoe-type row openers is being evaluated.

With the rapid conversion to direct seeding, other placement methods are becoming commonplace. As a rule, with direct seeding, all the nutrients are applied during the seeding operation. With egards to nitrogen management, the practice of mid-row banding and side-banding is commonplace. The question of interest is whether or not adding all the nutrients, i.e. N-P-K-S together in a single band can have a negative effect on the response of those individual nutrients. Recent work has shown that adding the nutrients P-K-S together in a single band did not negatively influence the response to nitrogen, indicating the feasibility of applying all nutrients together in a single band.

Nitrogen

Flax often responds well to nitrogen (N) fertilizer application when available soil N is low. For flax seeded on stubble, 35 to 80 kg/ha (31 to 71 lb./ac.) of N should be applied unless more specific information, such as a valid soil test, indicates otherwise.

Select a rate from within the suggested range based on moisture conditions. Use the lower end of the recommended range when soil moisture is low and yield is expected to be limited by drought. Use the higher end of the recommended range when soil moisture is to be maintained near optimum. For flax seeded on fallowed land, the response to N fertilization is generally lower. The relative effectiveness of the various N sources, forms, placements and application times is the same for flax as for other annual crops. N should not be placed directly with the seed.

Phosphorus

Response of flax to phosphorus (P) fertilizers is less pronounced or consistent than for most other annual crops. The flax plant appears to prefer high soil P levels from P fertilization of preceding crops, as compared to the application of a high rate of P on the flax crop itself. Rates of up to approximately 35 kg/ha (31 lb./ac.) of P2O5 are recommended for flax on soils with low levels of available P, as long as the fertilizer is not placed with the seed.

Potassium and Sulphur

Deficiencies of potassium (K) and sulphur (S) can limit production of all crops. However, these deficiencies are much more limited in extent than those of N and P, and are usually associated with specific soil types.

Sandier soils of the Dark Grey/Grey soil zones, as well as organic soils, are most frequently deficient in K. Sulphur deficiency is slightly more extensive, and can occur on sandy to loam soils of the Black through Grey soil zones. On irrigated land there is normally enough sulphur in the irrigation water to meet crop requirements. Approximately 34 kg/ha (30 lb./ac.) of sulphur is added to the soil with each 30 cm (12 in.) of irrigation water.

Iron and Zinc

Flax is more sensitive to low levels of iron (Fe) and zinc (Zn) in the soil than are most other Western Canadian field crops. In wet soil conditions, temporary iron deficiency can cause chlorosis yellowing of the leaves) in irregular patterns in the field. However, field tests have seldom shown any flax yield increase attributable to application of these micro-nutrients.

If a micro-nutrient deficiency is suspected, it should be confirmed through plant tissue testing. Following confirmation, measurement of response through small trial application should be undertaken before moving to full field scale application. Confirmation of a micro-nutrient deficiency is essential because research work has shown that applying micro-nutrients can depress flax yields if the nutrients were not truly deficient.

Growth and Development

Flax is an annual plant that grows to a height of 40 to 91 cm (16 to 36 in.), depending on variety, plant density, soil fertility and available moisture. Flax is self-pollinating, but from 0.3 to 2% outcrossing may occur under normal circumstances. Insects are the primary agents of outcrossing.
The life cycle of the flax plant consists of a 45- to 60-day vegetative period, a 15- to 25-day flowering period and a maturation period of 30 to 40 days (see Photos 8 and 9). Water stress, high temperature and disease can shorten any of these growth periods. Although there is a period of intense flowering, a small number of flowers may continue to appear right up to

maturity. During the ripening process, under high soil moisture and fertility, stems may remain green and new growth may occur leading to a second period of intense flowering.

Growth Stages

There are 12 distinct growth stages (GS) in the development of a flax plant **(see Fig. 1)**. In the illustration below, these GS's are shown as numbered line drawings. Each illustration has a title description and, in some cases, additional identifying information.

8. Growth stage 5 - stem extension

The flax plant has one main stem, but two or more branches (tillers) may develop from the base of the plant when plant density is low and soil nitrogen is high.

The main stem and branches give rise to a multi-branched, irregular arrangement of flowers. The plant has a short, branched taproot which may extend to a depth of more than 1 m (39 in.), with side branches stretching approximately 30 cm (12 in.).

Flowering

Flower opening begins shortly after sunrise on clear, warm days and petals are shed in the early afternoon. The flower parts, (petals, sepals and anthers) all occur in units of five (Fig. 2).

9. Growth stage 6 - buds visible, and 7 - first flowering

Flax varieties may be distinguished by the colour of the flower parts which can range from a dark to a very light blue, white or pale pink. The anthers are a shade of blue or are yellow. The style and filaments that bear the anthers are blue or colourless.

Ripening

The mature fruit of the flax plant is a dry boll or capsule. Ripening of the boll begins 20 to 25 days after flowering. The boll has five segments which are divided by a wall (septum) (Fig. 3). Each segment produces two seeds separated by a low partition called a "false septum", whose margin may be hairy or smooth, depending on the variety. With complete seed set, the boll contains ten seeds, though an average of six to eight seeds per boll is usual.

When ripe, the bolls of Canadian varieties are slightly gaping (Fig. 4), that is, the boll opens at the apex and the five segments separate slightly along the margin. The bolls rarely open so far as to allow the seeds to fall out.

Seeds

Flax seeds are flat, oval, and are pointed at one end. A thousand seeds weigh from about 5 to 7 g (less than 1 oz.), depending on variety and growing conditions. Seed of different varieties ranges in colour from light to dark reddish brown or yellow. Mottled seed, a combination of yellow and brown on the same seed, is the result of external, environmental conditions and is not an inherited characteristic.

The seed is covered with a coating (mucilage) that gives it a high shine and causes the seed to become sticky when wet. At times, this mucilage absorbs moisture from the air, causing the mature seeds to stick to the boll surface. This removes the shine on the seeds, giving them a scabby appearance which results in a reduced grade.

Weed Control

Weeds can be a serious problem in flax if left uncontrolled. Because flax does not shade the ground as much as cereal grains, weeds have an excellent chance to develop. Some weeds like wild buckwheat and red root pigweed are luxury users of nitrogen and will rob the flax crop of needed soil nutrients. Weeds not only compete with the growing flax crops to reduce yields, but also cause losses from dockage in seed shipments. Dockage amounts to thousands of tonnes annually and is charged directly against marketing costs.

Benefits of Early Treatment

Early removal of weeds is necessary to minimize crop losses caused by weed competition. Weeds in the seedling stage are more easily controlled by herbicides than at any other growth stage, and early treatment usually decreases the risk of injury to the flax crop. Risk of injury is also reduced by using correct water volumes, usually 110 l/ha (10 gal./ac.). The performance of many herbicides can also be affected by soil moisture conditions, air and soil temperatures, and other environmental factors.

Registered Herbicides

Many herbicides are available for the control of weeds in flax. Herbicides approved for flax are not necessarily approved for solin. As of 2001, only a limited number of herbicides are registered for use on solin. Additional herbicides are currently being evaluated for possible future registration. Contact your local agricultural representative or chemical company agent for information.

Herbicide Application Periods

There are three different herbicide application periods for the control of weeds in flax.

Pre-emergent

Pre-emergent herbicides include pre-plant soil-incorporated herbicides, and herbicides applied to weeds that emerge before the crop.

Post-emergent

Spring post-emergent herbicides (see provincial weed control guide for recommended product brands) are most effective when the weeds are in the seedling stage. These herbicides are applied after the weeds have emerged and the flax seedlings are 2 to 12 cm (1 to 5 in.) tall. Check the growth stages of both the crop and the weeds, and then follow recommended instructions on the herbicide label.

All post-emergent applications of herbicides must be applied within the pre-harvest interval indicated on the herbicide labels. This ensures that herbicide residues are reduced to acceptable levels when the crop is harvested.

Pre-harvest

Formulations of glyphosate registered (see provincial weed control guide for recommended product brands) for pre-harvest are applied when the flax is ripe, to control perennial weeds before the weed stems are cut when harvesting.

Weed Resistance to Herbicides

When choosing a product for weed control, records from previous years must be checked to ensure that the same herbicide (or members of the same herbicide group) is not used year after year on the same field. Frequent use of a herbicide group may lead to the development of resistance to that group of herbicides by a weed species.

Control of Volunteer Flax in Field Crops

Flax is not a strong competitor, so volunteer flax does not usually result in yield losses in competitive crops like cereals and canola. However, it can cause considerable difficulty at harvest time because it can remain green long after the crop is mature. This interferes with harvesting and can cause grain storage problems.

There is no herbicide that will provide sufficient control, or even suppression, of volunteer flax in broadleaf crops. However, quinclorac herbicide provides excellent control of volunteer flax in wheat. Quinclorac provides control of cleavers and a new mode of action for green foxtail control. Products or mixtures that contain dichlorprop (see provincial weed control guide for recommended product brands) will provide some suppression of volunteer flax in cereal crops. Use the maximum recommended rates. Products that include 2,4-D LV ester will have slightly more effect on the flax than 2,4-D amine or MCPA.

Because of the poor level of control likely to be achieved with herbicides, cultural practices are important in minimizing problems caused by volunteer flax. A competitive cereal crop managed for maximum competitiveness (early, shallow seeding; adequate, banded fertilizer; maximum seeding rate for the area) and treated with one of the herbicides mentioned above, should maximize the level of suppression.

Harvesting

Flax may be harvested by straight combining or by cutting with a swather and threshing later with a combine. Straight combining is the preferred method if the crop is thoroughly dry and free of weeds. Swathing followed by combining has become popular because this method assures drier seed than with straight combining, particularly if the crop is not uniformly mature or if weeds are present.

Flax is considered to be fully mature when 75% of the bolls have turned brown. After this stage has been reached, the crop may be swathed. If regrowth occurs in the fall, cut the crop when the greatest amount of ripe seed can be obtained. Do not delay the harvest too long because fall rains may cause weathering of the mature seed and frost may cause immature seed to turn black, resulting in a reduction in grade.

Considerable frost damage occurs in immature seeds when temperatures drop to the -3° to -5°C range (27° to 23°F), while leaves are severely damaged at -4° to -5°C (25° to 23°F) and stems at -6° to -7°C (21° to 19°F). Cutting or desiccating flax at an immature stage is not known to result in seed blackening, but yields will be reduced due to early termination of seed development. This will result in thin seeds of lower weight.

Swathing

When swathing, leave a stubble of about 10 to 15 cm (4 to 6 in.) to hold the swath off the ground and facilitate drying. To prevent blowing of the swath by strong winds, flax swaths should be rolled. Swathed flax may be ready to combine after exposure to a few days of dry

40. Sample of No. 1 Canada flax seed (magnified)

weather. The swath may be threshed when the leaves and stems are dry enough and the seeds rattle in the boll, or the seed has dried to the desired moisture level as indicated by a moisture meter. Although seed is considered dry enough for storage at 10% moisture (Canadian Grain Commission, Official Grain Grading Guide, effective August 1990), the crop may be harvested at a higher seed moisture if drying facilities are available. Usually, early-sown flax is easier to thresh than late-sown flax because it has a better chance to mature under drier conditions.

Keep the cutter bars of combines or swathers clean and sharp to ensure a smooth cut and to prevent accumulation of immature flax under the knife. Gumming of the cutting parts can be reduced by frequent application of water or kerosene.

Chemical Desiccation

Chemical desiccation may be used to accelerate drying of the crop and any weeds that may be present. It does not speed crop maturity, but will reduce the time from maturity to harvest. Potential advantages from this practice are:

- earlier harvesting;
- elimination of the need for swathing;
- reduction in combining time;
- less wear and tear on machinery;
- cleaner seed;
- reduction or elimination of the need for artificial drying.

A desiccant may be applied after 75% of the bolls have turned brown, which is the normal time of swathing. Studies at Morden, Manitoba have shown that yields are reduced if applications are made too early. For instance, swathing or desiccating at the

41. Sample of No.2 Canada flax seed. This seed shows the rime or scabbing which occurs in years with a wet harvest. This condition is not considered damage as long as the seed is otherwise sound.

42. Sample of heated to binburnt flax seed. Dark tan, orange or dark brown pulp is indicative of heat damage. Severely heated seeds are often accompanied by a heated odor.

25 to 50% brown boll stages, reduced yields by an average of about 10% and 5% respectively, due to premature termination of development of some of the seed.

Desiccated flax should be harvested as soon as possible after it is ready, to avoid capsule loss and weathering of the seed. For up-to-date information refer to the latest provincial recommendations, or consult your local agricultural representative.

Threshing

It is important that combine adjustments are correct for threshing flax. The seedcoat of flax is easily broken during threshing, particularly if the cylinder speed is too high and the seed is very dry. Damaged seed has reduced germination. If the seed is to be used for planting, great care in threshing is required. Yellow-seeded varieties are more susceptible to seed damage because of their thinner seedcoat.

It may be necessary to adjust the combine from time to time during the day depending on temperature, relative humidity and the condition of the flax. The manual provided with the combine should be consulted for correct settings.

Management of Straw

There are several methods of handling flax straw. Recent research has indicated that none of the methods appear to affect the yield of a succeeding crop of wheat. However, if the crop residues are removed by burning or baling, it must be kept in mind that the soil will become more vulnerable to erosion if summerfallow succeeds flax. Therefore, an additional cereal crop following flax is required to rebuild crop residues. Where continuous cropping is practised, rebuilding crop residue becomes less of a concern.

Storage of Seed

The percentage of flax grading Canada #1 is frequently very high, but dockage is often up to 10% (see Photos 40 and 41). Dockage can be reduced by controlling broadleaf weeds as well as grassy weeds — including volunteer cereals. If green weed seeds are present, they may raise the moisture of the flax seeds enough to cause heating and moulding. Removing this dockage before putting the flax into long-term storage is advisable.

Heated flax

Stored flax requires more attention than does stored wheat. Freshly harvested seed can maintain a high respiration rate for up to six weeks before becoming dormant. This, coupled with mould growth if the relative humidity of the air in the spaces between the seeds rises above 70%, can lead to heating. Once flax starts heating in a pocket, the heat will spread quickly - possibly throughout the entire bin. For this reason, flax seed should be cooled down after it is put into storage.
Flax seed can be safely stored at seed moisture levels of 10% or lower.

Tough flax contains from 10.1 to 13.5% moisture; damp flax is over 13.5% moisture (Canadian Grain Commission, Official Grain Grading Guide, effective August 1990).

Each year some heated flax seed shows up in the delivery system (see Photo 42). A wet harvest or an early fall frost will increase the percentage of heated flax. If aeration equipment is not available, bins of flax seed should be inspected frequently for problem spots until the seed has cooled down. Flax seed has an airflow resistance very similar to Polish-type canola (B. campestris). Periodic checking is necessary to detect the development of hot spots.

As in other oilseeds and cereal grains, moisture migration will occur in stored flax seed. Even though the seed is binned with uniform moisture, high moisture spots can develop by moisture migration. This usually happens in fall and early winter, although it can also occur in the spring.

Storage insects

Stored flax seed is not troubled by storage insects as frequently as cereal grains. Insects that can occur in stored flax are: saw-toothed grain beetle, confused flour beetle, merchant grain beetle and red flour beetle. Various fungus beetles and numerous mites can be found in seed that remains tough to damp in storage. Research in Manitoba has revealed that flax varieties vary in their susceptibility to the saw-toothed grain beetle. The rusty grain beetle occurs occasionally in carlots of flax. However, it is suspected that this insect feeds on cereal admixtures in the flax.

The optimum temperature for rapid growth of insects is in the range of 30° to 35°C (86° to 95°F). Their activity is greatly retarded by temperature below 18°C (64°F). If the grain is cool and dry, insects will generally not thrive. However, flax may be put into storage at an acceptable moisture content and temperature, but pockets of high moisture and temperature can develop later through moisture movement on convection currents and heat production by mould respiration which would encourage insect activity.

Flax in Animal and Poultry Feed for Better Health

Research News - **Rainbow Trout Fed Flax Oil Taste Good** - Rainbow trout fillets derived from fish fed flax oil were equal in flavour, odour and overall acceptability to fillets derived from trout fed fish oil, according to consumers and trained taste panelists at the University of Saskatchewan... **more**

Flax is unique in its high alpha-linolenic fatty acid (ALA) content. ALA is an omega-3 fatty acid, which contributes to good animal health. Flax is increasingly used as an ingredient in feeds for better animal health and for enriched food products.

Cattle Rations

Flax in cattle feed can improve the health of animals and boost healthy fats in the products.

For better health

The use of flax (called linseed in the feed industry) is being studied as a way to improve the immune systems in calves. The benefits of omega-3 fatty acids to cattle may be in preventing young animals from developing infections. Similarly, Agriculture and Agri-Food Canada's multidisciplinary team at the Dairy and Swine Research and Development Centre in Lennoxville, Quebec is studying reproductive and milking performance in animals on flax-enhanced rations. Research has shown flax in dairy cow rations has increased conception rates.

For better foods

Adding flax to cattle feed can also increase the content of healthy fats in meat and dairy products. These products provide consumers with foods that can have a healthier fat profile, and taste good. Such food choices appeal to all health-conscious consumers.

For information on enhancing the fat profile of milk and beef, click on links below:

- **Background Information on Key Fats in Milk and Beef** - Polyunsaturated fatty acids are those with two or more double bonds in their carbon backbone; they have many vital roles in human health. Dairy and beef producers are interested in increasing the content of two polyunsaturated fats in milk and beef products - namely, alpha-linolenic acid (ALA) and conjugated linoleic acid (CLA) because these fats are important in human nutrition ... **more**

- **Adding Linseed to Feed Enhances the Fat Profile of Milk** - The fact that ruminants digest their food in two stages presents challenges for dairy cattle and goat farmers, the main one being that rumen bacteria cannot easily metabolize some fatty acids, particularly polyunsaturated fatty acids like alpha-linolenic acid (ALA), the essential omega-3 fatty acid. Various methods of interfering with the bacterial metabolism of long-chain fatty acids in dairy cattle and goats have been tried... **more**

- **Adding Linseed to Feed Enhances the Fat Profile of Beef** - Several approaches have proven successful in protecting polyunsaturated fatty acids from biohydrogenation in the rumen. These methods have achieved favourable changes in the fatty acid content of beef... **more**

Equine Feeds

Many horse breeders and owners add milled, cooked or soaked flax seeds, or flax supplements or treats, to equine diets, especially if the horses are not fed on pasture for much of the year. The balance of omega-3 and omega-6 fatty acids in flax is important for horse health. Due to its high alpha-linolenic content, flax can eliminate dull, dry coats in animals, and the itching and scratching that can accompany them. Flax can also prevent colic in horses.

Hog Rations

The Flax Council has been involved in feeding trials in farrowing sows for improved pig production. Notably, flax rations improved sow fertility, allowing sows to be bred more quickly after weaning, and thereby increased the total number of piglets born over a span of three pregnancies. In addition, piglets born to sows on flax were shown to be heavier and healthier, with a lower mortality rate.

Pet Foods

Many pet food manufacturers include milled flax as a source of essential fatty acids in their premium pet foods. The flax balances the omega-3 and omega-6 fatty acid ratio of the food, and promotes healthy skin and coat in pets. The flax also contributes lignans, considered safeguards against tumor formation in pets.

"... consumers continue to treat their pets as well as, or better than, they treat themselves"[1].

Poultry Feed

Feeding hens a poultry feed containing flax is an excellent way to enhance the fat profile of the eggs. Eggs with extra omega-3 fats appeal to consumers who want to balance the fats in their diets.

For information on enhancing the fat profile of eggs, click on the links below:

- **The Novel Egg - Opportunities for Flax in Omega-3 Production** - Attemptingto fill a niche market as well as strengthen the healthy image of eggs , poultry research has aimed to develop omega-3-enriched eggs as a way of raising the level of omega-3 fatty acids in consumers' diets. The success of this research has created an exciting opportunity to incorporate and deliver enriched eggs into the rapidly growing functional food market and onto the plates of today's health-conscious consumers... **more**

- **Producing Omega-3 Enriched Eggs** - In recent years, researchers and egg producers have worked together to improve the omega-3 polyunsaturated fatty acid (PUFA) content of eggs by incorporating omega-3-rich foods like flax seed into the laying hen diet...**more**