Early Season Weed Control and Emergence Monitoring

I. Early Season Weed Control with In-Crop Herbicides

- Flax is a relatively poor competitor with weeds. Therefore, effective early season weed control is key to maximizing the yield of your crop. Weed control becomes even more critical if the flax crop emerged at a less than optimal rate or if your pre-seed or pre-emergent herbicide application was less successful than desired. Pay close attention to weed staging and product application recommendations to maximize in-crop weed control in flax.
- Reduced moisture at seeding will have weed control implications.
    1. Fewer weed seeds will germinate, so the early season weed flush may be delayed or reduced.
    2. Some pre-plant herbicides (Authority, Authority Charge, Avadex and Fortress MicroActiv) require a rainfall after application for activation of residual activity.
    3. Drought conditions may delay the environmental breakdown of herbicides with residual effects.
- The efficacy of some herbicides is affected by low moisture due to weeds being stressed and therefore more tolerant to the chemical. The flax crop may also be damaged if certain herbicides are applied during drought conditions. The application of certain herbicides (e.g. bromoxynil, quizalofop) to a flax crop under excess moisture stress may cause crop injury.
- Currently, only three different groups of herbicides (1, 4 and 6) are registered for in-crop use on flax and there is little overlap between the weeds controlled by each of these groups. This makes it challenging to use herbicide rotation for controlling the development of resistance. See Table 1 (next page) for a summary of the in-crop herbicides registered for use on flax.
- Early bud stage is the latest stage at which any broadleaf herbicide can be applied to flax.
- Flax is very sensitive to many herbicides, so ensure that your sprayer is well rinsed before spraying flax.
- Monitor the environmental conditions at the time of application to minimize crop injury. Flax is sensitive to some of the registered Group 4 and 6 herbicides, especially under warm and humid conditions.
- Only one application of MCPA and quizalofop-containing products are allowed per season on flax.
- There are several factors that may reduce in-crop herbicide efficacy:
    - Rainfall shortly after application can reduce the activity of some herbicides.
    - Water quality and chemistry can reduce the efficacy of some herbicides (e.g. clethodim).
    - Extreme environmental conditions (moisture, temperature, humidity) and poor fertility can negatively impact the effectiveness of herbicides.
- If tank mixing, follow label instructions for the order in which different chemicals should be added, as mixing in the wrong order may result in crop injury or reduced weed control.
- Always follow the most restrictive label directions and use precautions when tank mixing.
- The use of pest control products that are not registered for flax or that are applied outside of the recommended pre-harvest interval can result in trade issues related to maximum residue limits (MRLs).
- Provincial crop protection guides, product labels and manufacturers are important sources of information for herbicide-related information.
- Choose the right product and apply at the right stage, in the right conditions, and at the right rate to maximize the efficiency of weed control, to prevent the development of resistance and to minimize crop damage.

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Table 1. In-crop herbicide options for flax

Herbicide	Crop stage	Group	buckwheat, wild	chickweed	cleavers	cow cockle	dandelion	hemp-nettle	kochia	lamb's quarters	mustard, ball	mustard, wild	pigweed, redroot	shepherd's purse	smartweed, annual	sow-thistle, annual	stinkweed	thistle, Canada	thistle, Russian	volunteer canola	barnyard grass	foxtail, green	foxtail, yellow	oat, wild	Persian darnel	volunteer cereals
			Weeds Controlled (most common and those with confirmed herbicide resistance)																							
			Broadleaved Weeds																		**Grassy Weeds**					
Bentazon	≥ 5 cm (2")	6		√	√					√		√	S	√	√		√	√	√, S**	√						
Bromoxynil[¶]	5 cm (2") to early bud stage*	6	√			√			√**	√		√	√		√		√		√							
Bromoxynil + MCPA (amine, ester or K salt)[¶]	5 cm (2") to pre-bud stage[λ]	4,6	√			√		√	√**	√	√	√	√	√	√		√	TG	√	√						
Bromoxynil/MCPA ester[¶]	5 cm (2") to early bud stage*	4,6	√			√			√	√	√	√	√**	√	√		√	TG	√	√						
Bromoxynil/MCPA ester + Poast Ultra[¶]	5-10 cm (2-4")	1,4,6	√			√			√	√	√	√	√**	√	√		√	TG	√	√	√	√	√	√	√	√
Clethodim	all	1																			√	√	√	√	√	√
Clethodim + Curtail M	5-15 cm (2-6")	1,4	√				SR		S	√		√	√	SS	√	√	SR	√		√	√	√	√	√	√	√
Clethodim + Bromoxynil/MCPA ester**[¶]	5 cm (2") to pre-bud stage[λ]	1,4,6	√			√			√	√	√	√	√**	√	√		√	TG	√	√	√	√	√	√	√	√
Clethodim + MCPA ester[¶]	5 cm (2") to pre-bud stage[λ]	1,4	√**	√**			√**	√,S**	√**	√	√	√	√**	√	√**	√**	√	√,TG**	√**	√**	√	√	√	√	√	√
Clethodim + Lontrel 360	5-10 cm (2-4")	1,4	√															√			√	√	√	√	√	√
Clopyralid	5-10 cm (2-4")	4	√															√								
Clopyralid + Quizalofop**	5-10 cm (2-4")	1,4	√															√			√	√	√	BT		√[σ]
Clopyralid + MCPA amine or ester[§¶]	5-10 cm (2-4")	4	√				√		√**	√	√	√	√**	√			√	TG		√						
Clopyralid + Poast Ultra[¶]	5-10 cm (2-4")	1,4	√															√			√	√	√	√	√	√
Clopyralid + Poast Ultra + MCPA ester[¶]	5-10 cm (2-4")	1,4	√						√**	√	√	√	√**	√			√	√		√**	√	√	√	√	√	√
Clopyralid + Clethodim**	5-10 cm (2-4")	1,4	√															√			√	√	√	√	√	√
Clopyralid + Clethodim + MCPA ester**[¶]	5-10 cm (2-4")	1,4	√						√**	√	√	√	√	√	√	TG	√	√		√	√	√	√	√	√	√
Clopyralid/MCPA ester[¶]	5-15 cm (2-6")	4	√				SR,TG		S	√	√**	√	√	√,SS**	√	√	SR	√,TG**		√						
Curtail M + Poast Ultra[¶]	5-15 cm (2-6")	1,4	√				SR		S	√		√	√	SS	√	√	SR	√		√	√	√	√	√	√	√
Curtail M + Centurion/Select[¶]	5-15 cm (2-6")	1,4	√				SR		S	√		√	√	SS	√	√	SR	√		√	√	√	√	√	√	√
Clobber M + Independence[¶]	5-15 cm (2-6")	1,4	√							√	√	√		√			√	√			√	√	√	√	√	√
MCPA (amine, ester or Na salt)[¶]	5 cm (2") to pre-bud stage[λ]	4	√**	√**			√**	√,S**	√**	√	√	√	√**	√	√**	√**	√	√,TG**	√**	√**						
Poast Ultra[¶]	all	1																			√	√	√	√	√	√
Poast Ultra + MCPA ester[¶]	5 cm (2") to pre-bud stage[λ]	1,4							√**	√	√	√	√**	√			√			√**	√	√	√	√	√	√
Quizalofop	all	1																			√	√	√	BT		√[σ]

Adapted from the 2021, SK and MB crop protection guides. Check product labels for application rates, complete list of weeds controlled, and restrictions (environmental conditions, soil characteristics, adjuvant and surfactant requirements, water volume, number of applications, buffer zones, weed stages, re-cropping, re-entry periods and pre-harvest intervals).

[¶]may cause crop injury under certain environmental conditions or depending on rates used. Refer to product label(s) for more details and tips on how to reduce injury.

*crop most tolerant at 5-10 cm (2-4")

**only certain products/formulations

[λ]apply at early growth stages to minimize crop injury (some products)

[§]amine 600g ai/L formulation only; ester 500 and 600 g ai/L formulations only

[σ]volunteer oats best controlled when product applied prior to tillering

Type of control: BT=before tillering, S=suppression only, SR=spring rosettes only, SS=spring or small seedlings only, TG=top growth only

II. Emergence Monitoring

Germination vs. Emergence

Germination is the process of the emergence of the seedling from the seed coat. Emergence is the appearance of the recently germinated seedling above the soil.

If moisture was sufficient at seeding, flax seedlings should begin to emerge from the soil anywhere between 5 to 10 days after seeding, depending on seeding depth and soil temperature.

One way to work towards optimizing flax performance on your farm is to determine the plant population and calculate emergence rate. Relating these numbers back to the seeding rate used, the environmental conditions and other factors at seeding can help determine management practices for the growing season and adjustments that can be made next year.

<u>Steps to determine actual plant population and emergence rate:</u>

1. At 1.5 to 2 weeks after seeding, count the number of plants per square metre or foot in a few representative locations in the field and calculate the average. This number is the plant population. To maximize yield potential, the minimum desired population for flax is 300 plants/m^2 (28 plants/ft^2) and the maximum is 400 plants/m^2 (37 plants/ft^2).

2. Determine the seed density (based on seeding rate):

$$\text{\# seeds per ft}^2 = \frac{\text{seeding rate (lb)}}{\text{1 ac}} \times \frac{\text{1000 seeds}}{\text{TSW (g)}} \times \frac{\text{1000 g}}{\text{2.2 lb}} \times \frac{\text{1 ac}}{\text{43,560 ft}^2}$$

or

$$\text{\# seeds per m}^2 = \frac{\text{seeding rate (kg)}}{\text{1 ha}} \times \frac{\text{1000 seeds}}{\text{TSW (g)}} \times \frac{\text{1000 g}}{\text{1 kg}} \times \frac{\text{1 ha}}{\text{10,000 m}^2}$$

3. Calculate the emergence rate:

$$\text{\% emergence} = \frac{\text{plant population per unit area (ft}^2\text{ or m}^2\text{)} \times 100}{\text{seeds per unit area (ft}^2\text{ or m}^2\text{)}}$$

A typical emergence rate for flax is 50 to 60% but seed quality, agronomic factors and environmental conditions at seeding may have a further influence.

The implications of reduced crop emergence/establishment are increased weed competition, increased crop variability, delayed maturity and reduced yield.

If the emergence rate and/or the plant population is lower than what you were expecting, here are some possible explanations:

1. <u>Seeding rate too low</u>
   - The recommended seeding rate for flax is between 500 and 800 seeds/m^2 (47 to 74 seeds/ft^2). This accounts for a typical emergence rate of 50 to 60% and should produce a plant population of 300 to 400 plants/m^2 (28 to 37 plants/ft^2).
   - Seeding rates should be adjusted for both germination rate and seed size because these will directly impact the resulting plant population.
     - For example, for a target seeding rate of 45 lb/ac (50 kg/ha), you would need to plant 50 lb/ac (56 kg/ha) for a seed lot with 90% germination, or 56 lb/ac (63 kg/ha) to compensate for a germination rate of 80%.

    - Similarly, a seed size difference of 0.5 g at a 90% germination rate can mean the difference of seeding at 44 lb/ac (49 kg/ha) versus 47 lb/ac (53 kg/ha).
- Yellow-seeded varieties should typically be seeded at a 10 to 15% higher rate than brown-seeded varieties due to the thinness of their seed coats, which are more susceptible to damage.
- A sample of a seed lot can be sent to a licensed seed testing facility to determine the seed size/thousand seed weight and percent germination. You can calculate seed size by taking a representative sample of the lot, counting out 3 sets of 100 seeds, weighing each set of 100 seeds, averaging the 3 weights together and then multiplying that by 10. The resulting number is the thousand seed weight (TSW).
- TSW and germination details can typically be obtained from the seed grower or retailer from which you purchased Certified seed.

2. <u>Seeded too deep</u>
- To determine if seeding depth is the reason for poor emergence, gently dig down into the seed row to locate seeds and measure that depth. Also take note of the condition of the seeds that you locate.
- The recommended seeding depth for flax is 0.75 to 1.5" (2 to 3.8 cm), depending on the moisture conditions at seeding.
- Flax is a smaller seeded crop, so the amount of food reserves in the seed available for the developing seedling are limited. If seeded deeper than 1.5" (3.8 cm), it is very likely that the seedling will deplete the seed reserves before emerging from the soil and will die. The longer the emerging seedling is underground, the greater the exposure to seed and soilborne diseases.
- If the seeds you located are at a soil depth that falls within the recommended seeding depth range for flax, then poor emergence is due to another factor.

3. <u>Poor quality seed planted</u>
- Indicators that less-than-optimal quality seed was planted are: a lower-than-expected emergence rate, seed that did not germinate even when seeded into adequate moisture or abnormal seedlings (e.g. dead root or leaf tissue, curled roots or stems, missing roots or stems) that never reached the soil surface.
- Flax seed that is damaged may not germinate properly due to damage to the embryo, water not entering the seed properly during the very early stages of germination or the entry of pathogens into the seed.
- Seed that has been chemically treated can have reduced germination and/or vigour. Farm-saved flax seed that was harvested from a crop treated with a pre-harvest application of glyphosate is not recommended for planting due to possible negative effects on crop establishment. Flax seed that is treated with Vitaflo-brand products is only recommended for seeding within 18 months of treating.
- Damaged seed can be cracked, split, shrivelled, weathered, frozen or diseased. The use of a seed treatment can prevent undesirable microorganisms from entering damaged seeds and infecting the embryo or the emerging seedling. The use of some seed treatments on damaged seed may reduce seed germination and vigour.
- Flax seed coats are relatively thin, especially those of yellow-seeded varieties, and therefore can be susceptible to damage, especially during harvest.
- Seed lots are commonly tested for germination but can also be assessed for vigour. The vigour score gives an indication of how quickly and uniformly the seed will germinate and emerge from the soil under less-than-ideal conditions.
- Some seed testing labs indicate that a vigour test result can be used as the emergence rate in the seeding rate calculation while others suggest that the difference between a germination test result and a vigour test result represents the expected mortality rate in the field. Alternatively, vigour can be substituted for germination in the seeding rate calculation. Talk to your seed testing lab to determine how to apply the results of a vigour test to your seeding rate calculation.

4. <u>Lack of moisture</u>
- Soil-to-seed contact is very important for flax, especially under dry conditions.

- Lack of moisture at seeding will result in reduced and/or variable crop emergence. Often, some of the seeds will germinate and emerge with the limited moisture available at seeding, while the remainder will stay dormant until more moisture is received. This produces a crop with two different stages of development which can lead to weed control and harvest challenges.
- Reduced moisture at seeding will also have weed control implications (see Section I).
- Flax can be seeded as deep as 1.5” (4 cm) when trying to place the seed closer to moisture.

5. Seed rot/seedling blight
   - Seedlings affected by seed rot/seedling blight pathogens at very early stages may not fully germinate or may be weak or abnormal. Look for wilted seedlings with a narrow band of shrivelled stem or shrivelled and/or brown to reddish brown roots. Dead plants may also be present.
   - In flax, seed rot and seedling blight are caused by a variety of species of seed and soil-borne fungi (*Alternaria*, *Colletotrichum*, *Fusarium*, *Pythium*, *Rhizoctonia*) and infection by these pathogens may occur at any growth stage. *Rhizoctonia* prefers warm, loose soil, *Fusarium* proliferates in warm, dry soil and *Pythium* does best under cool, wet conditions.
   - Seed treatments are specifically designed to combat seed and soil-borne pathogens and there are four currently available for use on flax (Insure Pulse, INTEGO Solo, Maxim 480FS and 3 Vitaflo products). See the April edition of Flax on the Farm for more information.
   - Other ways to avoid seed rot/seedling blight pathogens are to plant high-quality seed and to follow a one-in-four year rotation to limit the build up of disease in the soil. To specifically control *Rhizoctonia*, do not seed flax into summer fallow, avoid legumes and sugar beets in the rotation, ensure a firm seed bed and seed early.

6. Cutworms
   - Cutworms are the larvae of a family of moths called noctuids.
   - Signs of cutworm damage are patchy emergence in the drier areas of the field, plants that have stems cut off at the soil surface and wilted and/or yellowing plants. Similar damage can be caused by wireworms but these insects seldom damage flax.
   - The presence of cutworms can be confirmed by digging down 1 to 2” (2.5 to 5 cm) in the soil in a variety of locations within or on the edge of a section of recently damaged crop and looking for larvae. The main identifiers of these larvae are that they are hairless (smooth-skinned) and curl up when disturbed. The economic threshold for most species of cutworms in flax is 4 to 5 larvae/m^2 or a 25 to 30% stand reduction. Several registered insecticide options exist.
   - A cutworm identification and management field guide for the Prairies is available from Agriculture and Agri-Food Canada.

7. Cold temperatures
   - Flax seed germination is affected by cold soil temperatures and young flax seedlings can be damaged by frost.
   - The minimum temperature for germination of flax seed is between 1 and 5ºC (34 to 41ºF). The optimum temperature for germination is between 7 and 10ºC (45 to 50ºF). Even though seed may germinate at relatively low temperatures, warmer temperatures result in more uniform germination.
   - Although flax is quite frost-tolerant, seedlings can be damaged by frost (see point 10 below).

8. Soil crusting
   - A heavy rainfall after seeding can cause the soil to crust. The force of large droplets combined with a high rate of rainfall can disintegrate soil aggregates and cause small particles to block surface pores. When the modified soil structure dries, it forms a cement-like layer on the soil surface which prevents seedlings from emerging, water from penetrating and gases from exchanging.
   - Soils low in organic matter, having limited crop residue on the surface, or that are heavily cultivated are the most prone to crusting.

- If your soil is at risk of crusting, increase your seeding rate and do not seed deep to give the crop a greater chance of emerging.

9. Herbicide residue or drift
   - Early indications of herbicide damage are: dead or damaged seedlings (e.g., dead tissue on leaves, chlorotic leaves or growing points, red/purple pigmentation of stems or leaves, bent stems, cupped leaves, twisted stems). Susceptible broadleaf weed seedlings in the same field will show similar symptoms.
   - Crop rotation is an important consideration as some herbicides applied to the preceding crop may negatively impact the flax crop up to 4 years later. Low moisture conditions, as well as soil type, pH and organic matter content can delay the breakdown of residual herbicides and amplify injury effects to sensitive crops registered to be planted the following season. Refer to the provincial crop protection guides, product labels, manufacturers and/or the March edition of Flax on the Farm for more detailed information.
   - Flax is highly sensitive to the broadleaf herbicides glyphosate and glufosinate, such that it is often damaged by herbicide drift from nearby crops. It is critical to adhere to the minimum buffer zones listed for herbicides when spraying nearby crops and to increase these if spraying under less than ideal conditions.
   - Consider using a drift control agent when spraying nearby crops.

10. Frost damage
    - Frost damage to flax is not very common as the crop is quite frost tolerant. Newly emerged seedlings (cotyledon stage) are tolerant to -2 to -4ºC (25 to 28ºF) and those at the 2-leaf stage are tolerant to -5.5 to -8ºC (18 to 22ºF) if they are hardened off by cool days prior to the frost.
    - Symptoms of frost damage are wilted plants, dead or dying leaf tissue (e.g., dark green, brown or black in colour or crispy), tissue that appears water-soaked, water-filled or spongy, or dead plants. Frost canker, or frost banding, is a condition where the main stem is girdled at or near the ground causing the plant to either fall over and die or send out several tillers.
    - Excessive residue on the soil at seeding will delay soil warming and can make seedlings more susceptible to frost damage (see point 12 below).

11. Fertilizer damage
    - Flax is highly sensitive to seed-placed fertilizer, so mid-row or side banding is recommended.
    - The primary symptom of fertilizer injury is reduced crop establishment from decreased germination and seedling damage. Fertilizer damage is directly caused by the components of the product; salt inhibits the seed from absorbing water, and certain elements damage developing seedlings due to their toxicity. The resulting stressed embryos and seedlings are more susceptible to opportunistic soil microbes and environmental stresses.
    - Dry conditions tend to intensify fertilizer injury, especially if ammonia-containing fertilizers are used.

12. Too much straw/residue
    - Large amounts of residue on the soil surface from the previous crop can physically impede the emergence of the flax crop, especially if it was planted deeply. Uneven residue distribution will lead to gaps and patchy emergence.
    - Residue on the soil surface delays the warming of the soil and can slow germination, reduce seedling growth and produce spindly seedlings.
    - Large amounts of residue can also make newly emerged seedlings more susceptible to frost damage by diminishing the insulating properties of the soil and causing greater swings in day/night temperatures compared to bare soil.
    - Excess residue can trap moisture in wet years, causing iron chlorosis symptoms to be more pronounced.

If your flax crop emerged well but the plants are not healthy, some possible explanations are:

1. Pale green or yellow leaves
   - Micronutrient deficiency
     - Flax is sensitive to deficiencies in iron (Fe), manganese (Mn) and zinc (Zn), especially under wet conditions in calcareous soils. Plants suffering from this condition have pale green or yellow leaves (chlorosis) with distinct green veins. Zinc deficiency (chlorotic dieback) may also be seen in soils that test high for phosphorous and low for zinc. Symptoms unique to zinc deficiency include: greyish-brown or bronze spots on younger leaves, leaves closely bunched together and stunted growth. Flax plants typically grow out of the condition when the soil dries out, but maturity is usually delayed. If conditions persist, terminal buds may die, plants may begin tillering and yield loss may occur.
     - Calcium (Ca) deficiency is not common but causes "wither-top" symptoms, such that the tip of the plant bends abruptly downwards 2 to 4" (5 to 10 cm) from the tip and begins to die. The symptoms often appear following the period of rapid growth just before flowering. This condition is often associated with water-logged soils and may be more prevalent in soils that are acidic and higher in clay content. Symptoms are very similar to low-dosage glyphosate drift.
     - Boron (B) deficiency causes chlorosis and in severe cases growing point death resulting in secondary branching.
     - Research has shown that often no benefit is gained from applying the deficient micronutrient, and therefore the application of a micronutrient to a small area is recommended before applying to the entire field, so that the response of the plants can be observed. Both soil and plant tissue tests are recommended to confirm a micronutrient deficiency and determine residual levels in the soil.

   - Macronutrient deficiency
     - Symptoms of macronutrient deficiencies can be difficult to diagnose visually since many are similar to those caused by other issues such as herbicide injury. Therefore, soil and tissue tests are typically required for confirmation of which nutrient is lacking.
     - Nitrogen is a major component of protein, DNA and chlorophyll. If lacking, the chlorophyll content of the leaves is reduced resulting in yellowing or paling of the oldest leaves. Plant growth and tillering will also be reduced if nitrogen levels are insufficient.
     - Phosphorous is important for root and shoot growth, stem strength, flower and seed production and is essential for many cellular processes within plants. Deficiency symptoms include stunted growth and purpling or browning of plant tissue often along the leaf margins (older tissues first). Phosphorous has low mobility and solubility at low temperatures and is inaccessible in dry soils.
     - Potassium is a key nutrient for many cellular processes in plants and contributes to the ability of plants to tolerate environmental stresses and to fight off insects and disease. If lacking, plants are stunted and the lower leaves will have burnt (yellow to brown) tips or edges.
     - Sulphur plays an important role in protein and chlorophyll formation and is involved in seed production. New growth will be yellow or pale green in colour if sulphur is limiting.
     - To prevent macronutrient deficiencies, a soil test before seeding is recommended to determine the reserve levels of macronutrients in the soil and how much fertilizer to apply. At a minimum, fertilizing to the level of what the flax crop will remove (Table 2) is a good soil stewardship practice.

Table 2. Macronutrient removal by flax (lb/ac)

	Removal (lb/ac) with seed and straw			
Crop (yield)	**N**	**P**	**K**	**S**
Flax (24 bu/ac)	71	20	44	14

Adapted from the Saskatchewan Ministry of Agriculture website (www.saskatchewan.ca)

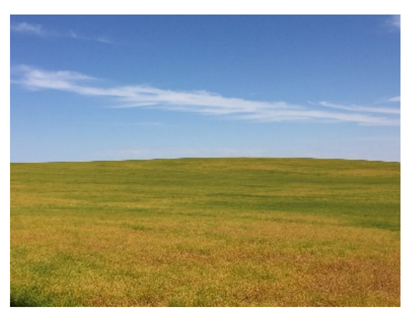
- Wet soil
  - Flax has a relatively shallow root system, so can be overwhelmed with standing water. Under these conditions, roots are deprived of oxygen and their function is impaired. Water and nutrient uptake are soon reduced causing the plants to slow their metabolism and begin recycling nutrients. Early signs of too much water are wilted plants and pale green or yellow older leaves.
  - Deficiencies in iron, manganese and zinc often appear under wet conditions in calcareous soils (see point 1 above)
  - Crop injury may occur if certain herbicides are applied to flax when under stress from too much moisture.

- Herbicide damage
  - One of the first symptoms of herbicide damage is chlorosis, or a yellowing or paling of the leaves and/or growing points. More advanced symptoms may include: dead tissue on leaves, red/purple pigmentation of stems and leaves, bent stems, cupped leaves and twisted stems, depending on the herbicide involved.
  - Flax may also become chlorotic (also called flash) or wilted after the application of some of the registered Group 4 and 6 herbicides but will recover after a few days.
  - Application of certain herbicides under high temperatures and/or humidity or to stressed plants (e.g. drought, excess soil moisture, low fertility, diseased, insect damaged, etc.) can lead to crop injury.

2. <u>Dead plants or plants shaped like a shepherd's crook</u>
   - The classic symptom of Fusarium wilt is a plant that is bent like a shepherd's crook. Plants infected by this pathogen may also be wilted or dead. If wilted, typically only the leaves on one side of the plant will be affected, unlike the entire plant as is the case with seedling blight.
   - If you suspect that Fusarium is the culprit, soil and plant samples can be tested for the presence of the fungus (*Fusarium oxysporum* f. sp. *lini.*).
   - Fusarium is a soil-borne fungus that attacks roots. Quantities of the fungus rapidly build up in the soil if susceptible crops are seeded one after another. Spores can survive in the soil up to 10 years.
   - The pathogen that causes Fusarium wilt prefers warm soils, so seeding early means that the plants are at a later developmental stage when infection typically occurs, making them inherently more resistant.
   - This disease is the reason that flax grew so well on freshly broken land when pioneers settled the west and then yielded so poorly when grown the year after on the same soil.
   - All currently registered flax varieties are at least moderately resistant (MR) to Fusarium wilt meaning that some infection will still occur at a relatively low level as long as rotation recommendations are followed.
   - Growing Certified seed will ensure the maximum tolerance to the disease, and a minimum rotation of 3 years between flax crops will reduce the spore load in the soil to an acceptable level.

Flax is a very resilient crop, so despite having early challenges it will, except in the most extreme cases, compensate for seedling damage, low emergence rates and herbicide injury by branching out and taking longer to mature.

Flax Disease Survey
A Saskatchewan flax disease survey is planned for 2021 and permission to survey fields must be granted by landowners. If you are interested in supporting provincial pest survey efforts please sign up here:
https://ca.surveygizmo.com/s3/50060966/Pest-Monitoring-Sign-up
or call Michelle at SaskFlax at the number listed below.



For more information about emergence monitoring and early season weed control in flax contact the following:

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Other Useful Links:

1. Considerations for a dry spring
   - Considerations for planting into dry seedbeds-Manitoba Agriculture and Resource Development
   - Effect of spring frost on emerging crops-Manitoba Agriculture and Resource Development
   - Seed treatment options in a dry spring-Manitoba Agriculture and Resource Development

2. Pesticides
   - PMRA Pesticide Product Label Search
     - Online
     - App
   - Provincial Crop Protection Guides
     - Alberta
     - Saskatchewan
     - Manitoba
   - List of available biopesticides-CABI BioProtection Portal
   - Herbicide carryover risk maps
     - Saskatchewan
     - Manitoba
   - Pesticide resistance
     - Manage Resistance Now
     - Resistant Wild Oat Action Committee
   - Sprayer tank cleanout tips

3. Crop rotation
   - Principles and Practices of Crop Rotation-Saskatchewan Ministry of Agriculture
   - Crop Rotations and Yield Information-Manitoba Agricultural Services Corporation
   - Crop Rotations in Direct Seeding-Alberta Agriculture and Forestry

4. Seeding rate calculators
  - Alberta Agriculture and Forestry
  - FP Genetics

5. Fertilizer guidelines
- International Plant Nutrition Institute
- Manitoba Soil Fertility Guide-Manitoba Agriculture and Resource Development
- Saskatchewan Ministry of Agriculture
  - Nitrogen Uptake
  - Phosphorous Uptake
  - Potassium Uptake
  - Sulphur Uptake
- Alberta Agriculture and Forestry
  - Alberta Fertilizer Guide
  - Phosphorus Fertilizer Application in Crop Production
- Irrigation
  - Fertilizer Requirements of Irrigated Grain and Oilseed Crops-Alberta Agriculture and Forestry
  - Irrigated Crop Recommendations-Alberta Agriculture and Forestry
  - Irrigation Economics and Agronomics-Irrigation Crop Diversification Corporation (ICDC)

6. Weather data
- AAFC Agroclimate Maps for the current season
- Alberta Crop Report-Alberta Agriculture and Forestry
- Current and Historical Alberta Weather Station Data Viewer-Alberta Agriculture and Forestry
- Crop Report-Saskatchewan Ministry of Agriculture
- Weather conditions and reports-Manitoba Agriculture and Resource Development

7. Pests and beneficials
- Prairie Pest Monitoring Network
- Alberta Insect Pest Monitoring Network
- Field Heroes
- Cutworms
  - Prairie Pest Monitoring Network cutworm monitoring protocol
  - Manitoba Agriculture and Resource Development cutworm factsheet
  - Alberta Agriculture and Forestry cutworm survey results map
  - Alberta Agriculture and Forestry cutworm specimen submission

8. Labs offering plant disease/disorder testing
- Saskatchewan Ministry of Agriculture Crop Protection Laboratory (Regina, SK)
- Manitoba Agriculture and Resource Development Crop Diagnostic Centre (Winnipeg, MB)
- A&L Canada Laboratories (London, ON)
- Agvise Laboratories (Northwood, ND)
- BDS Labs (Qu'Appelle, SK)
- SGS BioVision (various locations in AB, SK and MB)

9. Labs offering testing for herbicide carryover in the soil
- A&L Canada Laboratories (London, ON)
- AGAT Laboratories (various locations in AB and SK)
- ALS (Edmonton, AB and Saskatoon, SK)
- Element (Edmonton, AB)
- Saskatchewan Research Council (Saskatoon, SK)

10. Labs offering testing for pesticide residue in plant tissue
- A&L Canada Laboratories (London, ON)
- AGAT Laboratories (various locations in AB and SK)
- ALS (Edmonton, AB and Saskatoon, SK)
- Saskatchewan Research Council (Saskatoon, SK)