Mustard Production Manual

SASKATCHEWAN MUSTARD DEVELOPMENT COMMISSION

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Plant description

Types of mustards and their uses

Mustard is a broadleaf, cruciferous, cool-seasoned annual oilseed crop produced primarily for the condiment market. Two species and three types of mustards are grown in Western Canada: *Sinapis alba* (yellow mustard) and *Brassica juncea* (brown and oriental mustards). The different types of mustard vary in physical appearance (see how to distinguish mustard from canola) and use. In this document the term crucifers will be used to describe all plants in the Brassicaceae family (formerly Cruciferaceae family). The term brassica will be used to refer to plants in the genus *Brassica.*

Brassica juncea

Yellow mustard has a yellow seed coat and is primarily grown for the North American condiment industry, where it is used to produce traditional yellow mustard condiment, mayonnaise and certain salad dressings. The seed of yellow mustard also contains a water-binding mucilage that has been used as a binding agent and protein extender in prepared meats.

Brown mustard has a reddish brown to dark brown seed coat while oriental mustard seeds are primarily yellow to dark yellow. Both brown and oriental mustards are used to create products that are spicier than yellow mustard condiments. Brown mustard is primarily exported to Europe where it is used to produce condiments and specialty mustards like Dijon mustard. Oriental mustard is primarily grown for export to Asian countries where it is used to produce condiments. Oriental mustard oil is used as a spicy cooking oil in some Asian countries, but is not consumed as an oil in North America.

A fourth type of mustard, *Brassica carinata*, commonly called “carinata” or “Ethiopian mustard,” has been grown in Saskatchewan; interest in this crop was primarily for bioplastic or biofuel industries. Due to changing markets, however, there has been little to no carinata production in the province for several years. This production manual therefore focuses on yellow, brown and oriental.

Growth stages

Both species of mustard follow a very similar life cycle and growth pattern to canola (*Brassica napus*) and can be staged in a similar manner. The BBCH staging system is a uniform system that can be used to stage many different crops and weeds. It will be used as a guide to the principle mustard growth stages referred to throughout this manual.

Throughout the life cycle, mustard plants have eight principle growth stages: germination, leaf development, stem elongation, inflorescence emergence, flowering, fruit development, ripening and senescence. The staging system is organized by these principle growth stages and expanded to reflect the progression through each stage. Staging of crops is important for optimal timing of harvest and pest management strategies. A complete staging system is presented in the following table and the growth stages will be referenced throughout the remaining sections of the manual.

Code	Description
Principle growth Stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from the seed
07	Hypocotyl with cotyledons emerged from the seed
08	Hypocotyl with cotyledons growing towards the soil surface
09	Emergence: cotyledons emerge through the soil surface
Principle Growth Stage 1: Leaf Development	
10	Cotyledons completely unfolded
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1..	Stages continuous until…
19	9 or more leaves unfolded
Principle Growth Stage 2: Side shoot development	
20-29	Occur in many other species, but is of low relevance to mustard.
Principle Growth Stage 3: Stem elongation	
30	Beginning of stem elongation: Rosette
31	1 visible extended internode
32	2 visibly extended internodes
33	3 visible extended internodes
3..	Stages continuous until…
39	9 or more visibly extended internodes
Principle Growth Stage 4: Vegetable plant part development	
40-49	Occur in Brassicaceae, but are relevant for harvesting vegetable parts (ex: broccoli)
Principle Growth Stage 5: Inflorescence emergence	
50	Flower buds present, still enclosed by leaves
51	Flower buds visible from above (green buds)
52	Flower buds free and level with the youngest leaves
53	Flower buds raised above the youngest leaves
55	Individual flower buds (main inflorescence) visible but still closed
57	Individual flower buds (secondary inflorescences) visible but still closed
59	First petals visible, flower buds still closed (yellow buds)
Principle Growth Stage 6: Flowering	
60	First flowers open
61	10% of flowers on main raceme open, main raceme elongating
62	20% of flowers in main raceme open
63	30% of flowers in main raceme open
64	40% of flowers in main raceme open
65	Full flowering: 50% of flowers in main raceme open, older petals falling
67	Flowering declining: majority of petals fallen
69	End of flowering
Principle Growth Stage 7: Development of Fruit	
71	10% of pods have reached final size
72	20% of pods have reached final size

73	30% of pods have reached final size
74	40% of pods have reached final size
75	50% of pods have reached final size
76	60% of pods have reached final size
77	70% of pods have reached final size
78	80% of pods have reached final size
79	Nearly all pods have reached final size
Principle Growth Stage 8: Ripening	
80	Beginning of ripening: seed green, filling pod cavity
81	10% of pods ripe, seeds dark and hard (yellow for yellow and oriental mustards)
82	20% of pods ripe
83	30% of pods ripe
84	40% of pods ripe
85	50% of pods ripe
86	60% of pods ripe
87	70% of pods ripe
88	80% of pods ripe
89	Fully ripe
Principle Growth Stage 9: Senescence	
97	Plant is dead and dry
99	Harvested product

How to distinguish mustard from canola

	Canola (*Brassica napus*)	Brown or oriental mustard (*Brassica juncea*)	Yellow mustard (*Sinapis alba*)
Seedling	 Heart-shaped cotyledons and hairless leaf stalks. First true leaves have a hairless upper surface with scarce hairs on the underside of the leaf.	 Heart-shaped cotyledons and hairless leaf stalks. First true leaves are covered with hairs on both the upper and lower leaf surfaces. Hairs on leaves are less dense than on yellow mustard leaves.	 Heart-shaped cotyledons have a few hairs on the edges and upper surface. Stems and leaf stalks are densely pubescent (hairy). First true leaves have a dense covering of hair on both the upper and lower surfaces.
Adult leaves	 Adult leaves are dark bluish-green, waxy and either hairless or with a few sparse hairs near the leaf margin. The leaves are rounded and partially clasp the stem.	 Leaves are pale green with hairs on the first leaves and leaf margins. The lower leaves will be deeply lobed, while the upper leaves will be narrower and not lobed. The leaf will terminate higher up on the petiole and will not clasp the stem.	 Leaves are light-green, densely pubescent and deeply lobed. The leaf will terminate higher up on the leaf stalk and will not clasp the stem.
Flowers	 Yellow flowers.	 Pale yellow flowers.	 Yellow flowers that are smaller than canola flowers.

	Canola (*Brassica napus*)	Brown or oriental mustard (*Brassica juncea*)	Yellow mustard (*Sinapis alba*)
Stems	Hairless and smooth	Hairless and smooth	Pubescent with lots of small hairs on the stems and petioles
Pods	 Long narrow pods with a smooth, medium conical peak. Pods are usually positioned at a right angle to the stem.	 Smooth long, conical beaked pods. The pods are usually positioned 45° to the stem.	 Pods are long, flat and covered with small hairs. Pods are positioned at a right angle to the stem.
Seeds	 Seeds are black in colour and spherical to oval in shape. They are larger than brown and oriental mustard but smaller than yellow mustard seeds.	Brown mustard  Seeds are reddish brown to dark brown in colour and are 2 mm or less in diameter. Seeds are spherical or oval in shape. Oriental Mustard  Seeds are predominately yellow to dark yellow in colour with some seeds light brown to dark brown. Oval in shape with a width of 1.2 to 2 mm and a length of 1.6 to 3 mm.	 Seeds are light creamy yellow to yellow with the occasional seed being light or yellowish brown. Seeds are spherical or oval in shape with a diameter of 2 to 3 mm.

Adaptation, field selection and rotational characteristics

Adaptation

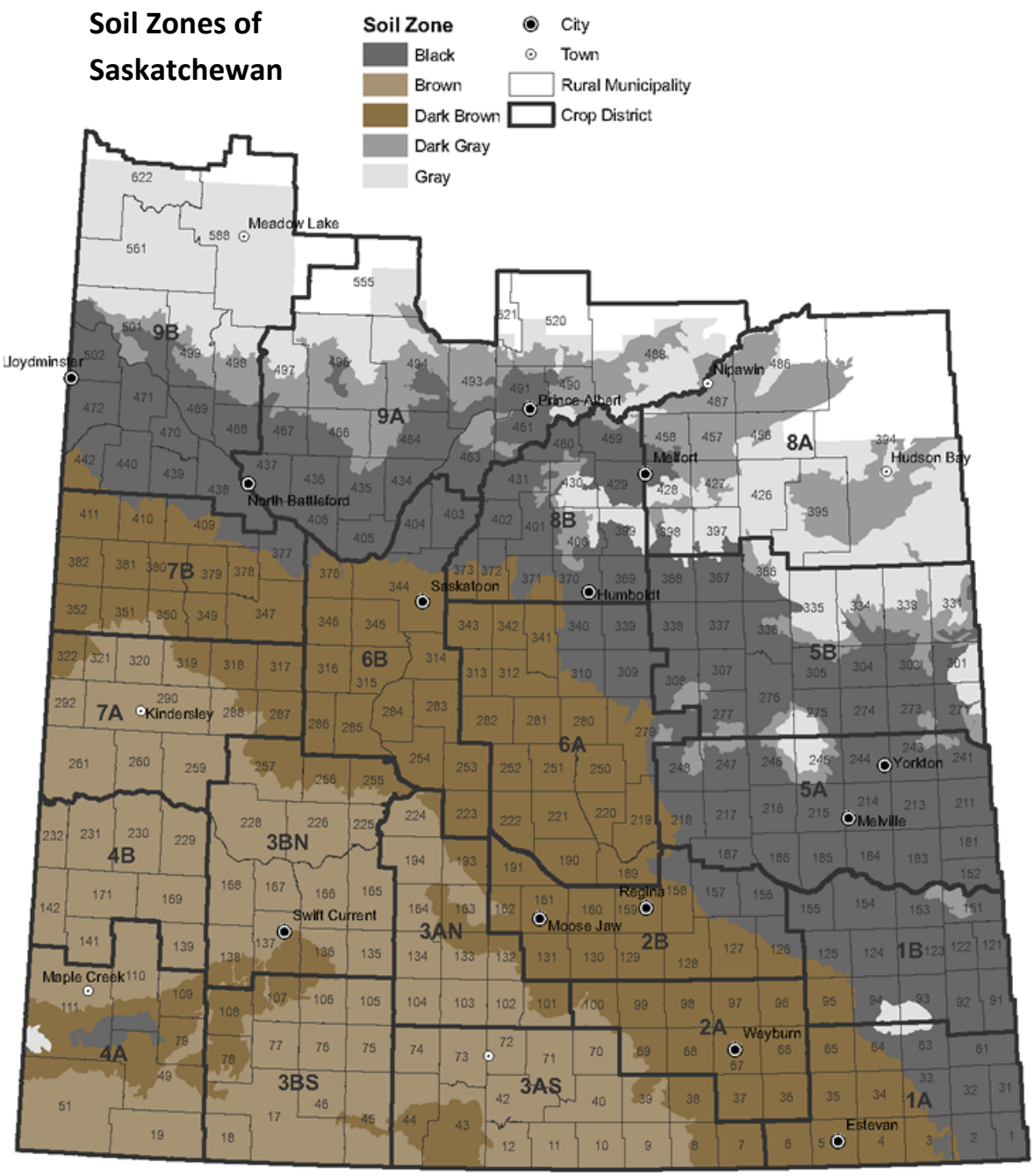
Mustard is a cool season crop that performs well in a short growing season with crops reaching maturity in 90 to 100 days. Seeds can germinate in soil temperatures as low as 4.4˚C. Seedlings are fairly frost-tolerant allowing for early seeding. Mustard seedlings are more tolerant to late spring frosts than canola and flax seedlings.

Mustard is more drought tolerant than other oilseed crops and is well suited to the Brown and Dark Brown soil zones in the southern Prairies. However, mustard will not tolerate extended periods of drought and should not be grown in dry sand and dry sandy loam soils or in areas where flooding may occur. When soils become waterlogged there will be poor aeration in the root zone resulting in stunting of mustard plants.

Field preparation

To obtain optimum emergence and vigorous plants, the seedbed should be firm, moist and uniform. A firm seed bed will provide good seed-to-soil contact, even planting depth and quick moisture absorption by the seed resulting in uniform germination

For zero tillage systems, residue management is very important to ensure even emergence. Uniform residue distribution will help to ensure even seedbed moisture and result in uniform emergence. Prior to growing mustard, residue should be finely chopped and uniformly spread during harvest and/or harrowed in the fall when the straw is dry if further distribution is required. When residue spreading is inadequate there will be patchy emergence due to variable moisture (poor seed to soil contact) and soil temperatures in areas where residues are low vs high. Zero tillage systems will help conserve more moisture than conventional tillage.



Crop rotation

Crop rotation is a very important part of any crop production system. An ideal rotation would be one in which mustard crops follow a cereal crop. To adequately control volunteers and prevent grain contamination and down grading, a break of several years between canola and mustards is important. Contamination of mustard grain with canola containing genetically-engineered (GE, or "GMO") traits is problematic because mustard is a non-GMO crop and marketed as such. As a result, canola and mustard should not be grown in the same rotation unless there is an adequate break to remove all volunteers and prevent contamination.

Another consideration is disease. Mustard is susceptible to many of the same diseases as canola and other broadleaf crops. To manage disease levels, a break from susceptible crops is required. One important disease is sclerotinia stem rot caused by *Sclerotinia sclerotiorum,* which can also cause disease in canola, field pea and several other field crops and broadleaf weeds. Sclerotinia is often not a problem in mustard when grown in drier regions. However, sclerotinia risk may be greater when mustard is grown in rotation with lentils. If sclerotinia was a problem in the past, a break from susceptible crops prior to growing mustard is recommended particularly because the presence of sclerotia in the harvested grain can lead to downgrading.

All mustard types can be hosts to the clubroot pathogen (*Plasmodiophora brassicae*) as well; substituting canola with mustard to minimize risk of clubroot introduction or infection is not recommended. This would provide a host for the pathogen, while also increasing risk of contamination of mustard with canola volunteer seed. The same precautions and management strategies as outlined by the Saskatchewan Ministry of Agriculture should be considered with mustard production if clubroot is a concern.

Mustard is traditionally grown in the Brown and Dark Brown soil zones where moisture is often limiting. Crop rotation can be used to influence soil moisture by rotating between deep and shallow rooted crops. A list of the common crops and their rooting depths is found in the following table.

Deep	Moderate	Shallow
Alfalfa	Barley	Field pea
Sunflower	Canola	Flax
Chickpea	Mustard	Lentil
	Wheat	

Herbicide residue consideration

When selecting a field to grow mustard, particular attention should be paid to the previous use of herbicide and any applicable re-cropping restrictions. The list of products and the length of cropping restrictions can be found in the following table. Be sure to cross-reference with the product label as well as the current Saskatchewan Agriculture Guide to Crop Protection for the most up-to-date information. Note that some products may have additional considerations for certain years during or following excessively dry conditions; make sure you are aware of increased carry-over risk for products used prior to the mustard crop. If applicable, products will include details about moisture thresholds and additional re-cropping restrictions.

Product	Special considerations	Years[1]
Metsulfuron (*Ally*, *Accurate*, also a component of *Express Pro*)	--	4
Ethametsulfuron (*Muster Toss N Go*)	*Muster Toss N Go* is registered for use in brown and oriental mustard from the four-leaf stage up until flowering. However, brown and oriental mustards are not tolerant to *Muster Toss N Go* applications prior to the four-leaf stage.	2
Imazamox (*Solo*) +fluroxypyr (*Altitude FX2*) +clopyralid, *Lontrel Dry* (*Tensile*) +bentazon (*Viper*)	Tensile is no longer produced but may still be in distribution system.	2
Florasulam/fluroxypyr+MCPA (*Outshine*)	Not applicable	2

[1]Years refers to the number of winters that must pass between application and seeding of mustard.

Mustard may be seeded the year after application of the following herbicides or co-pack combinations of those herbicides:

- All Group 1 grass control herbicides
- 2,4-D
- 2,4-DB
- Aim/CleanStart
- Avadex
- Axial Xtreme
- Barricade II
- Basagran brands
- Broadband
- Bromoxynil
- Bromoxynil/ 2,4-D
- Bromoxynil/ MCPA
- Dicamba (cereal rates)
- Dicamba/mecoprop/MCPA
- Dichlorprop/2,4-D
- DyVel
- DyVel DSp
- Eclipse
- Enforcer D or M
- Eptam
- Florasulam/Fluroxypyr + MCPA (*Stellar*, *Stellar XL* only)
- Fluroxypyr + 2,4-D
- Fluroxypyr + MCPA
- Harmony co-packs
- Heat
- Kerb
- Korrex
- Liberty
- Linuron
- Lontrel
- MCPA
- MCPB/MCPA
- Mecoprop
- Paradigm
- Pinnacle
- Pixxaro
- Prestige XC
- Pulsar
- Retain
- Salute
- Simplicity
- Tandem
- Thifensulfuron/tribenuron
- Tribenuron
- Triton K
- Varro

Herbicides not listed above have no recommendation for re-cropping to mustard. In many cases this means that a successful bioassay (strip of mustard grown in the field without injury symptoms) must be grown to determine safety before seeding the entire field to mustard. Contact the manufacturer of products not noted above for further information.

Varieties

Type and Variety	Yield[1]	Plant Height (cm)	Hydroxylbenzyl Glucosinolate (umol/g seed)	Allyl Glucosinolate (umol/g seed)	Mucilage[2] (cS*ml/g seed)	Resistance to White Rust[3] 2a	2v	Fixed Oil (% seed)	Protein (% Seed)	Seed Weight (g/1000)	Maturity (days)
Open-Pollinated Yellow (% Andante)											
Andante[4]	100	107	142	n/a	88.6	R	R	28.4	35.2	5.8	87
AAC Adagio[5]	102	-4	-3	n/a	+8.2	R	R	+1.7	-2.2	-0.7	+7
AAC Yellow 80[6]	108	+3	-5	n/a	-5.0	R	R	+0.8	-0.4	0.0	0
AC Pennant[4]	99	-11	+6	n/a	-43.9	R	R	+1.1	-0.9	-0.1	+6
Open-Pollinated Brown (% Centennial Brown)											
Centennial Brown[4]	100	126	n/a	12.6	n/a	S	S	35.8	30.0	3.0	86
Amigo[7]	93	-17	n/a	+1.3	n/a	R	S	-1.6	+0.7	-0.3	+12
AAC Brown 120[8]	112	0	n/a	-0.6	n/a	R	R	-0.6	-0.2	+0.7	+8
Hybrid Brown (% Centennial Brown)											
AAC Brown18[9]	119	+3	n/a	-0.4	n/a	R	S	+1.7	-1.3	-0.1	86
Open-Pollinated Oriental (% Cutlass)											
Cutlass[4]	100	115	n/a	11.6	n/a	R	S	41.0	29.1	2.8	91
Forge[4]	97	+10	n/a	+0.6	n/a	S	S	-2.1	+0.5	-0.2	+1
AAC Oriental 200[8]	106	+9	n/a	+0.1	n/a	R	S	-4.0	+0.9	-0.1	+1
AC Vulcan[4]	98	+1	n/a	+0.8	n/a	R	S	-0.4	+0.4	+0.1	0

[1] Yield data not collected by area.

[2] Mucilage in yellow mustard is a measurement of viscosity of aqueous extracts from seed.

[3] Varieties are rated S (Susceptible) or R (Resistant) to White Rust strains.

[4] Data from 1999-2012 Co-operative Mustard Test. Yield % of check: 124 station years for yellow mustard, and 117 station years for brown and oriental mustard.
[5] Data from 2009-2012 Co-operative Mustard Test (29 station years).
[6] Data from 2019 Co-operative Mustard Test (11 station years).
[7] Data from 2008-2010 Co-operative Mustard Test (21 station years).

[8] Data from 2016-2018 Co-operative Mustard Test (22 station years).

[9] Data from 2017-2018 Co-operative Mustard Test (14 station years).

Contract requirements and other varietal factors can influence variety selection. For yellow mustard, there is variation in the amount of mucilage for the three different varieties which may be a factor for variety selection. AAC Adagio has the highest mucilage levels when compared to AC Pennant and Andante. More information about registered varieties can be found in the SaskSeed Guide.

Hybrid mustard

AAC Brown 18 is a new hybrid mustard that was registered in 2018. It is the first brown mustard hybrid developed using an improved hybrid breeding technique called the Ogura cytoplasmic breeding system, which was developed by Agriculture and Agri-Food Canada Saskatoon Research and Development Centre (AAFC-SRDC). AAC Brown 18 has consistently delivered a 19% yield increases over the open-pollinated check variety Centennial Brown. There are yellow and oriental mustard hybrids being bred as well.

With AAC Brown available to producers, current agronomic practices are being researched to accommodate the hybrid. The seeding rate as of now is recommended to be 4-6 lbs per acre with a target plant stand of 7 to 11 plants/ft^2 (70 to 110 plants m^2) which is the current recommendation for open-pollinated varieties. Nitrogen use efficiency and rates will likely be different for the hybrid as well. Currently there is research being conducted to fine the optimal seeding rate and nitrogen rate for AAC Brown 18.

Hybrid mustard has many benefits, the main one is an increased yield over open-pollinated varieties. Consistently AAC Brown 18 has yielded at least 19% greater than Centennial Brown. Other benefits of the hybrid include increased biomass accumulation, quicker emergence and ground cover, which can help the crop to be competitive with weeds. AAC Brown 18 has many desirable properties but producers should keep in mind that the seed cost of the hybrid is higher than open-pollinated varieties. AAC Brown 18 also has half of the erucic acid content of the open-pollinated check which is being selected for in European markets. AAC Brown 18 has many desirable properties but producers should keep in mind that the seed cost of the hybrid is higher than the open-pollinated varieties.

Production

Seed treatments

There are several seed treatments registered for use on mustard seed to control a variety of insects and diseases. The information below is current for the 2022 growing season. Please see the Saskatchewan Agriculture Guide to Crop Protection for the most-up-to date information.

Product	Diseases	Insects
*Helix Vibrance** PCP#31454	Seed-borne blackleg (*Leptosphaeria maculans*), seed-borne *Alternaria* spp. and the seedling disease complex (damping off, seedling blight, seed rot, root rot) caused by *Pythium*, *Fusarium* and *Rhizoctonia* spp.	Flea beetles (early-season)
*Prosper EverGol** PCP#30363	Seed rot, damping off, seedling blight and early season root rot caused by *Pythium*, *Rhizoctonia*, *Fusarium*, seed-borne *Alternaria* spp. and seed-borne blackleg (*Leptosphaeria maculans*)	Flea beetles
*Rancona V RS** PCP#30217	Seed rot, damping off and seedling blight caused by *Fusarium* spp. or *Rhizoctonia solani*; seed-borne blackleg (*Leptosphaeria maculans*)	--
Insure Pulse PCP#32011	Seed rot, seedling blight, root rot caused by *Fusarium* spp., *Rhizoctonia solani*, *Pythium* spp., *Alternaria brassicae*, and blackleg (*Leptosphaeria maculans*)	--
*INTEGO Solo** PCP#31324	Seed rot or pre-emergent damping-off caused by *Pythium* spp.	--
NipsIt INSIDE 600‡* PCP#28975	--	Flea beetles
Sombrero 600 FS‡‡* PCP#30505	--	flea beetles
Fortenza‡‡‡* PCP#30899	--	Flea beetles and cutworms
Lumiderm*‡‡‡‡ PCP#30894	--	Flea beetles and cutworms
Fortenza Advanced*‡‡‡ PCP#30899	--	Flea beetles, early-season flea beetles and cutworms

*Available to commercial seed treaters only
‡for *Brassica carinata* (Ethiopian mustard) only
‡‡for condiment type mustard only
‡‡‡ for oilseed and condiment mustard including *Brassica carinata* (Ethiopian mustard)
‡‡‡‡ for oilseed type mustard only

Although most of these products must be applied by certified seed treaters, there many commercial seed treaters throughout the province. If your seed supplier is not certified to apply a seed treatment, contact the Ministry of Agriculture for seed treaters in your area.

Some seed treatments can be combined; check the product labels or the Saskatchewan Agriculture Guide to Crop Protection for specific details about possible combinations of products.

Treated mustard seed stored longer than 6 months should be tested for germination prior to planting, as storing treated seed beyond recommended storage conditions may negatively impact germination compared to untreated seed. Storage limitations may differ for each product.

Fertility

Soil testing

Soil testing is a very important tool for optimizing fertility. Soil tests will identify which nutrients are deficient and provide a recommendation for levels of nutrients needed to correct the deficiencies. Fertility recommendations should be based on realistic target yields which will vary with the type and variety of mustard and are based on available soil moisture reserves and an estimation of the growing season precipitation.

Nitrogen

Nitrogen (N) is essential for vigorous growth, high yield and quality of mustard. Nitrogen is essential in the production of plant proteins and chlorophyll and is needed in the greatest amount compared to the other macronutrients. Nitrogen uptake and utilization takes place throughout the entire growth cycle. When plants are deficient in N they will have pale green to yellow foliage and the plants will often be spindly. Yellowing of the older leaves is another indication that the mustard may be deficient in N. Nitrogen is distributed from old leaves to younger leaves in the plant resulting in deficiency symptoms first appearing on older leaves. On a canopy level, when a crop is N deficient, the canopy will likely be thin and open and the flowering period will be shortened leading to reduced pod set and lower yield.

Mustard, like canola, responds strongly to N fertilization and yield increases of 30% or more are common. Recommended rates of N are 50 to 80lbs/acre of actual N in soils where N is deficient, but it is best to follow the soil test recommendations. Increasing N levels above the soil test recommendation does not always lead to further increased yields. The highest response to added N occurs when moisture is not limiting. In dry years, N rates near the low range of the recommendation will be adequate since realistic target yields will be lower than when moisture is not a limiting factor.

Mustard seed is small and very sensitive to seed-placed N fertilizer, similar to that of canola. If nitrogen is required in excess of the safe rates for seed-applied N, or if moisture is limiting, should be side banded or mid-row banded. For the best response, N should be applied at the time of seeding with a direct seeding system. When this is not possible, N fertilizer should be banded in the fall. If topdressing nitrogen use a urease inhibitor to minimize volatilization losses.

Safe rates of seed-placed urea N for mustard in actual pounds per acre (good-to-excellent soil moisture):

	1 inch spread*			2 inch spread*			3 inch spread*		
Soil texture	(disk or knife)**			(spoon or hoe)			(sweep)		
	Row spacing			**Row spacing**			**Row spacing**		
	6"	9"	12"	6"	9"	12"	6"	9"	12"
	SBU* **			**SBU**			**SBU**		
	17%	11%	8%	33%	22%	17%	50%	33%	25%
	Pounds of actual N per acre‡			**Pounds of actual N per acre‡**			**Pounds of actual N per acre‡**		
Light	10	5	0	20	15	10	30	20	15
Medium	15	10	5	30	20	15	40	30	20
Heavy	30	15	10	40	30	20	50	40	30

* Width of spread varies with air flow, soil type, moisture level, amount of residue and other soil conditions, so it must be checked under field conditions.

** Some openers give less than 1" spread.

*** Seedbed Utilization (SBU) is the amount of the seedbed over which fertilizer has been spread. Thus, it reflects the relative concentration of fertilizer. SBU (%) is the width of spread divided by the row spacing multiplied by 100.

‡Values are for actual N. To get the pounds of Urea (46-0-0) to apply per acre, divide by 0.46

Phosphorus

Phosphorus (P) is important for the establishment of a healthy and robust root system. Deficiency will result in dwarfed plants with stunted roots. With severe deficiency, plants will be spindly, and if extremely deficient, mustard plants will have purple discolouration of the stems and leaves as well as be stunted.

Phosphorus is immobile in the soil so it is important that P is placed within or near the seed row. To avoid fertilizer damage, no more than 15 to 20lbs P_2O_5/acre should be placed with the seed under good moisture conditions. If the soil test recommendation is greater than the seed-placed guideline, some of the phosphate fertilizer should be split-applied in the side or mid-row band with the N.

Potassium

Potassium (K) aids in water uptake and starch production. Adequate levels are required for disease, drought and frost tolerance. As with N, a major symptom of K deficiency is the yellowing of the leaf margins. Potassium deficient plants will have reduced growth, smaller leaves and thinner stands.

The majority of soils in Saskatchewan have sufficient K levels. Grey and sandy soils, however, can be deficient. Use a soil test to determine the rate required to correct any deficiency.

Sulphur

Sulphur (S) is a major constituent of seed protein and as a result, mustard plants have a higher S requirement during crop flowering, but will utilize S from the soil throughout the growing season until seed filling is complete. Plants deficient in S will show yellowing of the newest leaves, stunted growth and smaller petals on pale yellow flowers. Unlike N, S is not mobile in the plant. As a result, deficiency symptoms will be seen in new leaves, flowers and pods. When deficiencies are marginal, visual symptoms may not be present, but yield losses can still be severe. Missing pods, small pods and missing and/or small seed will be the symptoms.

Mustard needs a constant supply of S throughout the growing season with an increased requirement at flowering, as S is a major constituent of seed protein. For mustard production, the general S recommendation is 15 lbs/acre of actual S as ammonium sulphate in the Brown and Dark Brown soil zones and 20 lbs/acre of actual S in the Grey and Black soil zones.

Mustard is very sensitive to the salt effect when ammonium sulphate is placed with the seed. Ammonium sulphate can be broadcast or side or mid-row banded. If S was missed during seeding, ammonium sulphate can be broadcast anytime up to first flower to rescue the yield of mustard. However, the earlier the ammonium sulphate is broadcast the better the chance of yield recovery, providing there is some rain to dissolve and move the ammonium sulphate into the soil for access by the roots.

Recommendations are based on the application of ammonium sulphate, not elemental S. If elemental S is applied to a field, it can take two or more years of adequate moisture for some conversion to the plant-available sulphate form.

Micronutrients

Micronutrient deficiency is typically not an issue for mustard production. As a result, such fertilization is not required unless indicated by a soil test. If deficiency symptoms are suspected, a tissue test plus application of the micronutrient in strip tests including untreated check strips should be conducted prior to fertilization of the entire field.

Top dressing and split application

It is best to apply all nutrients at the time of seeding to reduce application costs; however, in some years when moisture is limiting at the time of seeding this may not be the most economical approach. If moisture is limiting in the spring, the amount of N and S fertilizer should be reduced to obtain reasonable target yields. In the event of rain and increased yield potential, supplemental N fertilizer can be dribble banded using a split nozzle or drop tubes.

Seeding

Seeding depth

Mustard is a small seeded crop making shallow seeding important for even emergence and crop establishment. It is recommended that mustard is seeded at a depth of 0.5 to 1 inch (1.5 to 2.5 cm) into a firm, moist seed bed. When moisture is limiting, mustard can be seeded as deep as 2 inches (5 cm) to reach soil moisture. However, this may result in reductions in emergence and plant stand density and should not be common practice when moisture is not a major limiting factor or precipitation is in the forecast shortly after seeding.

Seeding rate

On the Prairies, mustard emergence is 50 to 80 per cent when moisture is not limiting. Due to its larger seed size, yellow mustard will have slightly better emergence than brown and oriental mustard. Research looking at thousand seed weight also identified that better emergence was found with heavier seed lots.

Due to the differences in seed sizes, the recommended rates for yellow mustard and for brown and oriental mustards will be different. For yellow mustard, the recommended seeding rate is 7 to 10 lb/acre (7.8 to 11.2 kg/ha) for a target plant stand of 7 to 11 plants/ft^2 (70 to 110 plants/m^2). For brown and oriental mustards, the recommended seeding rates are 4 to 6 lb/acre (4.5 to 6.7 kg/ha) for a target plant stand of 7 to 11 plants/ft^2 (70 to 110 plants/m^2). The lower seeding rate for brown and oriental mustards accounts for the smaller seed size which will result in more seeds per pound of seed.

Time of seeding

For mustard, early seeding is recommended and will be beneficial to obtaining full yield potential. Early planting will increase the likelihood of utilizing early spring moisture and will allow the crop to mature before the hottest part of the year.

Saskatchewan research indicates that mustard will benefit from yield increases with earlier seeding despite having reduced stand establishment. For all mustard types, earlier seeding resulted in higher seed yields. In a 2006-08 study in Saskatoon, Saskatchewan, yields of yellow mustard were found to increase on average by 1.4 to 2.2 bu/acre when the crop was seeded in early to mid-May versus late May to early June. Similar results were seen for brown and oriental mustard, with a 2.1 to 2.8 bu/acre yield increase on average when the crop was seeded early to mid-May versus mid-May to early June.

Pest control

Weeds and herbicide options

If not managed properly, weeds can be a serious problem and reduce the yield of mustard. Weeds compete for water and nutrients and may cause yield loss or reductions in grading. Mustard has the advantage over some other field crops in that it is very competitive and has the ability to outcompete weeds once the crop is established, particularly if good agronomy is practiced. However, if the weed population is high prior to crop establishment, the weeds will compete with the emerging crop at its most vulnerable stage, highlighting the need for an effective burnoff application or tillage regime. Weed management should involve an integrated approach including strong agronomy, proper crop rotations and herbicide applications.

Weeds of concern in mustard are similar to those in other crops. Mustard is marketed as free from genetically-engineered traits; contamination of harvested grain with canola could result in downgrading and reduced market access, and a deteriorated reputation of Canadian mustard. If canola and mustards are grown in the same rotation, it is important that a proper rotation is maintained and that all volunteers are controlled prior to seeding the mustard crop. It is always important to only use registered products for controlling pests in any crop, but it is especially crucial for mustard growers to keep this in mind as the industry is highly dependent on export markets. To ensure best practices are taken, be sure to read product labels, consult the Saskatchewan Ministry of Agriculture's Guide to Crop Protection, and check with the buyer.

The role of agronomy in weed management

Thorough weed control prior to seeding and throughout the crop rotation will help to reduce the weed populations and can be used to manage problematic weeds that are difficult to control in mustard or can result in downgrading. Agronomic practices that promote a uniform and vigorous crop stand with early canopy closure will improve the competitiveness of the mustard crop. The following agronomy tips can be used to increase the competitiveness of a mustard crop.

- **Use higher seeding rates.** High seeding rates will produce a dense crop stand with faster canopy closure that will more readily shade and out-compete weed seedlings.
- **Seed shallow.** Seeding shallow and into moisture will ensure quick emergence and strong, quick growing seedlings and a uniform crop stand. However, seeding depth may need to be adjusted to place seed onto moist soil.
- **Use narrow row spacing.** Narrow row spacing will increase the competitiveness of the crop through quick canopy coverage and shading of weeds.
- **Provide optimal fertility.** Optimal fertility at the time of seeding will produce healthy vigorous seedlings that can compete with weeds and withstand some insect and disease pressure. Targeting fertility (example side banding) so that the crop can access it easily and nutrients are isolated from weed roots is a way to influence crop competitiveness versus weeds.

- **Use clean seed.** Using clean, weed-free seed will prevent the introduction of new weeds seeds. Also using new healthy seed will result in a more uniform and vigorous crop.
- **Seed early.** Seeding a crop early will allow the crop to utilize early spring moisture and will also allow the crop to be more competitive and shade out later emerging weeds. Early control of perennial and winter annual weeds has been shown to provide increased yield benefits versus delaying control until immediately before later seeding dates.

Herbicides for weed control in mustard

Herbicides used for weed control in mustard can be discussed in two different groups: in-crop herbicides, and pre-harvest herbicides. Within in-crop herbicides, there are soil active herbicides typically applied prior to the seeding of the crop, and foliar herbicides applied after crop and weed emergence. Due to the limited selection of registered in-crop herbicides for mustard, it is important that good weed control is maintained throughout the crop rotation. Because of herbicide resistance concerns and for the best crop yield response, it is recommended that a combination of the herbicides listed below be used with an approach called "herbicide layering."

It is important that the timing, rates and pre-harvest intervals stated on the herbicide label be followed. Deviation from the application instructions listed on the label will alter the efficacy of the product and may result in herbicide residues higher than established Maximum Residue Limits (MRLs) which could reduce the marketability of the harvested grain.

Maximum Residue Limits (MRLs)

It is important to note that certain products, even if registered, may have market access concerns. To ensure the safety of Canadian food, maximum residue limits (MRLs) set the maximum allowable amount of a pesticide residue on a crop or in a processed crop product (e.g. oil or flour). Residue levels are typically assessed for pesticides registered on crops grown for food. MRLs even exist on imported food for pesticides or pesticide uses not registered in Canada.

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for setting MRLs in Canada. Similarly, importing countries set their own MRLs (also referred to as 'import tolerances') that Canadian crop exports are subject to. Trade issues between importing and exporting countries can arise due to variability in MRLs or a lack of established MRLs. Crop pesticide uses that may contribute to trade irritations have been flagged on product pages in the Saskatchewan Ministry of Agriculture's Guide to Crop Protection. Manitoba Agriculture and Saskatchewan Ministry of Agriculture have included such statements in their guides on products uses with known or potential MRL issues. More information on MRLs and 'flagged' products is available at http://keepingitclean.ca/ .

Producers can follow these practices to help prevent exceeding MRLs:

- Read and follow product labels, especially with respect to registered crops, maximum application rates, maximum number of applications per season, crop stage and pre-harvest intervals.

- Talk to your commodity buyer before applying a pesticide, especially for new pesticide chemistries, new products and products registered on new crops.

Soil active, in-crop herbicides

All soil active herbicides used in mustard must be applied to the soil prior to the seeding of the crop. All but one of these herbicides are very polar (the molecules of the herbicide chemical have strong positive/negative electrical charges) and will bind strongly to organic matter and clay. As a result, the use rate of those polar herbicides will vary depending on the organic matter and clay content of the soil it is used on. The other is less polar and its efficacy is affected by organic matter. This also means that heavy crop residue cover on fields may result in the very polar herbicides becoming bound to that residue, resulting in reduced activity. All but one of these herbicides are also very volatile, which means that some type of incorporation is required to prevent those herbicides from gassing off into the atmosphere.

There are four herbicide options registered for brown, oriental and yellow mustards (*Avadex*, *Fortress*, trifluralin and *Authority*) that can be applied to the soil prior to seeding, either in the fall just prior to freeze-up, or in spring once the field is dry enough to access. *Avadex* (triallate) is a Group 8 herbicide that is used only for wild oat control. Trifluralin (*Treflan, Bonanza, Rival*) products are Group 3 herbicides that can be used to control a variety of broadleaf and grassy weeds. *Fortress* contains the active ingredient from *Avadex* along with a reduced rate of trifluralin, and can control several grassy weeds and be used for suppression of many broadleaf weeds. *Authority* (sulfentrazone) is a Group 14 herbicide that may be applied to the soil surface without incorporation, prior to seeding or up to three days after seeding for the control of kochia only. *Edge* (ethalfluralin) is a pre-emergent Group 3 herbicide registered to control and suppress many broadleaf and grassy weeds in yellow mustard only.

Granular *Avadex* and *Fortress* formulations have an option for application in late fall, prior to freeze up, only without the need for immediate incorporation, whereas *Edge* and trifluralin require immediate incorporation to prevent losses from gassing off (volatilization) or exposure to sunlight (photodegradation). The application and incorporation instructions of the label should be read and followed carefully.

Authority relies on rainfall to incorporate it into the germination zone of the emerging kochia. Should there be too little rainfall after application then performance may suffer, but if too much rainfall occurs in a short time span, injury may occur to the mustard crop.

Post-emergent (foliar), in-crop herbicides

Post-emergent weed control in mustard is largely comprised of Group 1 herbicides for the control of grassy weeds, with the exception of *Muster Toss-N-Go*. *Muster Toss-N-Go* is a Group 2 herbicide, registered for use on brown and oriental mustards only.

Group 1 herbicides with the active ingredients clethodim (*Select, Centurion, Arrow*, *Shadow RTM, Advantage Clethodim 240, Independence, Clethodim 240, IPCO GraminX, CO-OP Patron II, Statue and*

Antler 240EC), sethoxydim (*Poast Ultra*) and quizalofop (*Assure II* for all mustards and *Yuma GL* for oriental mustard only) are registered to control grassy weeds in all three types of mustard. As with most other broadleaf plants, mustards are tolerant to Group 1 herbicides throughout the entire crop's life cycle. However, pre-harvest intervals are set on product labels for food residue purposes and weed control benefits are typically greatest when weeds and crops are small. Adequate weed control may still be achieved when grassy weeds are sprayed prior to the six-leaf stage with clethodim and sethoxydim and prior to tillering with quizalofop, but the yield benefit is greatest when the crop is less than four leaves (prior to growth stage 14).

Muster Toss-N-Go is a Group 2 herbicide that is registered for broadleaf weed control in brown and oriental mustards only. Yellow mustard tolerance to *Muster Toss-N-Go* is poor due to its close relationship with wild mustard. Brown and oriental mustards are tolerant to *Muster Toss-N-Go* only from the four-leaf stage up until the start of flower bud formation (growth stages 14 to 50). This herbicide targets broadleaf weeds.

In both brown and oriental mustards, *Muster Toss-N-Go* can be tank mixed with *Assure II* to provide control of both grassy and broadleaf weeds in one pass.

An MRL for quinclorac was recently approved by Codex Alimentarius, and three products are available with this active ingredient, both as a WDG (*Clever* and *Ingenious*) and as a solution (*Facet L*). Quinclorac is 75% WDG (at 55g/ac) or 227mL/ac of *Facet L* can be applied to brown & oriental mustard from 2-6 leaf stages. As this approval is still relatively recent, the buyer should be consulted to confirm if there are still market access concerns. Products containing quinclorac should not be applied more than once every 2 years.

Pre-harvest herbicides

Glyphosate (*RoundUp WeatherMax*) may be applied prior to harvesting mustard to control perennial weeds for the following season, but is not intended for rapid crop dry down. Glyphosate may provide harvest management benefits by killing off any green annual weed material present in a mature mustard crop. The perennial weeds controlled include quackgrass, Canada thistle, toadflax and dandelion. *RoundUp WeatherMax* is registered for use prior to mustard harvest when grain moisture is less than 30 per cent and crops are largely ripe. For effective perennial weed control, five to seven days must pass to allow the herbicide to translocate to the root systems of the weeds prior to harvest. Premature applications may result in glyphosate residues in harvested seed exceeding the MRL allowed which can cause problems with marketability of the harvested grain. To ensure greatest weed control and herbicide residue levels below regulated MRLs, it is important that application timing and pre-harvest intervals stated on the product label be followed. Note: Registration for pre-harvest use of *RoundUp WeatherMax* is done under the User Requested Minor Use Label Expansion (URMULE) program, and thus application is done at the risk of the applicator/producer.

Talk to your grain buyer before using a newly registered product or an existing product with new uses to ensure that MRLs will not be an issue.

Insects

Scouting

Regular scouting is important to determine pest presence and changes in insect populations in the crop. Crop staging, climatic conditions and an insect's life cycle can all be factors in considering what and when to expect insect pests. When monitoring, it is important to look for the presence of the insect, what life stages are present, damage to the plant and where the damage is. Another component to scouting and monitoring is determining how many insects are present. The method of counting insects will vary for different pests and can include counting the number of insects per square meter (e.g., grasshoppers), counting the number of insects per plant (e.g., diamondback moths and bertha armyworm) or using a sweep net to determine the average number of insects per sweep (e.g., cabbage seedpod weevil). When the insect pressure is known, economic or action thresholds can be used as a guide for control decisions. Economic thresholds will vary with the cost of the insecticide, the cost of application and the current value of the mustard crop as well as the insect pest in question.

Pests of Seedlings

Flea beetles - The main flea beetle species in Saskatchewan are crucifer (*Phyllotreta cruciferae)*, striped (*P. striolata*) and hop (*Psylliodes punctulata*). Flea beetles overwinter as adults and emerge in the spring, feeding on the cotyledons, leaves, apical bud tissue and stems of mustard plants. In July, larvae feed on root hairs. Adults emerging later in the season may "de-bark" seed pods.

The effect on the crop varies with the intensity of pest pressure, the part of the plant where damage occurs and the growing conditions. Flea beetles are more active with higher temperatures. Seedlings are most susceptible to serious flea beetle damage. Damage is most severe when the beetles attack the growing point of the plant. In cool moist conditions, scouting should include observing the underside of cotyledons for pitting and the stem for notching or girdling. Feeding on pods can result in premature shattering and grade loss.

Management: Seed treatments containing an insecticide are an effective method for controlling flea beetles. Current seed treatments require the insect to consume plant tissue for control. Seed treatments have a limited time in which they are effective. If the seedlings are growing slowly or flea beetle pressure is high, a foliar insecticide spray may be required. An action threshold of 25 per cent cotyledon surface removed (Assessing leaf area loss to flea beetles can be found here) is the recommended level of damage when a spray may be necessary to protect the seedling.

Striped flea beetle

Crucifer flea beetle

Crucifer flea beetle on canola pods

Cutworms - There are various species of cutworms found in Saskatchewan including: redbacked cutworm (*Euxoa ochrogaster*) in eastern regions; pale western cutworm (*Agrotis orthogonia*) in western regions; dingy cutworm *(Feltia jaculifera*); and bristly cutworm (*Lacinipolia renigera*) among others. Cutworm moths lay eggs in late summer, usually August and September. The females tend to deposit eggs in areas with green growth (weedy or crop), preferably in loose soil. Some species overwinter as eggs and hatch in the spring. Other species overwinter as larvae and will commence feeding earlier in the spring than species that overwintered as eggs. Species that overwinter as larvae will usually start to pupate from mid to late June, depending on climatic conditions. Cutworms that overwinter as eggs commence pupation near the end of June or early July.

Cutworm larvae generally feed most actively during the evening, at night and the early morning. Feeding damage differs between species. Some, such as the red-backed cutworm, remain below ground cutting off plants at or below the soil surface, while others such as the dingy cutworm feed above ground on foliar vegetation. Due to the reclusive nature of cutworms, monitoring can be difficult. Once the presence of cutworms has been verified, per cent stand reduction can be used as an estimate of damage. Since there are other potential causes for reduced plant stands, the presence of cutworms should be determined by digging in the soil. The best results will be to look near the newest area of missing plants.

Management: A foliar insecticide spray should be considered when there is 25 to 30 per cent stand reduction. There is no good predictive model for cutworm infestations and populations can be variable from year to year. There is also a seed treatment registered for cutworm control in mustard (see page 11). A resource published in spring of 2017 by Agriculture & Agri-Food Canada provides in-depth information about identification and management of cutworms on the Prairies. A downloadable version is available at: < https://drive.google.com/file/d/0B_Pg-Nb5Pst1VnFuZk1hb25ZWk0/view >

Redbacked cutworm

Dingy Cutworm

Red turnip beetle (*Entomoscelis americana*) - Red turnip beetle is an occasional pest of mustard in Saskatchewan. The adults are 7 to 10 mm long and easily distinguished by bright red bodies marked with black patches just behind the head and three distinct, black stripes running down the wing coverings. Eggs are deposited from early August to late October near the plants on which the adult beetles feed. Eggs remain dormant until late March to early May. Hatching occurs in the spring. The larvae are smoky black on top and brownish underneath. Larval development takes three to four weeks depending on climatic conditions and is normally completed by the end of May.

In May and June, infestations of both larvae and adults move into mustard crops, often from stubble fields of cruciferous crops (canola, rapeseed or mustard) or areas containing heavy stands of weeds of the mustard family. Crop damage usually occurs along field margins but may occur in patches throughout the crop if cruciferous volunteers were previously present. The larvae and adults feed on the cotyledons, true leaves, petioles and stems of the seedlings. Depending on the size of the plants and beetle populations, damage will vary from minor feeding on cotyledons and true leaves to complete defoliation, especially with seedlings. The late summer adults are not usually economically important.

Management: Red turnip beetle infestations can be reduced considerably through cultivation. Fall cultivation will bury eggs. Newly hatched larvae do not move well in the soil and burying the eggs can result in 75 to 100 per cent mortality of larvae the following spring.

Weed control, whether by cultivation or chemical methods, will indirectly control the larvae by destroying their food source.

Currently there are no insecticides registered for control of the red turnip beetle.

Red turnip beetle larvae

Pests at flowering and podding stages

Diamondback moth (*Plutella xylostell*) - The diamondback moth does not overwinter successfully in Saskatchewan. Economic infestations are usually the result of moths blown in on wind currents in the spring from the southern United States and Mexico. The amount of damage diamondback moth causes to mustard crops primarily depends on the part of the plant attacked, and the abundance and size of the larvae attacking the plants. Diamondback moth larvae feed on leaves, flowers, seed pods, the green outer layer of the stems, and the developing seeds within the older seed pods of canola and mustard. The amount of damage varies greatly, depending on plant growth stage, and larval density and size.

Diamondback moth develops through four life stages: egg, larva, pupa and adult. During the growing season this life cycle is repeated, with three generations being common if the moths arrive early and climatic conditions are favourable. It can take 21 to 51 days to complete one generation. After the first, the generations usually overlap in the field and in later generations all four life stages may be present in a field at the same time.

The adult moth is approximately 8 to 9 mm long with a wing span of 12 to 15 mm. The males have a series of yellowish wavy markings along the forewing margins that, when at rest, come together to form diamond-shaped marks.

The larvae are pale yellowish-green to green and covered with fine, scattered, erect hairs. Young larvae are leaf miners, feeding between the leaf surfaces. After about a week, the larvae start feeding externally on the leaves. At maturity the larvae are spindle-shaped and about 12mm in length. When disturbed, larvae wriggle backwards violently and may drop from the plant suspended by silken threads. The larvae eventually climb back onto the leaf and continue feeding.

There are naturally occurring wasp parasites, predators and disease that can reduce diamondback moth populations. High levels of parasitism are common in later generations of the insect.

Heavy precipitation events can have a significant negative impact on diamondback moth larvae. Fields should be scouted before considering chemical application for diamondback moth larvae following a heavy rain. Insecticides will have little or no effect on pupae. In addition, the pupae are often on the underside of leaves where contact is unlikely. Since the moths tend to lay their eggs in a short period of time (24 to 48 hours), targeting the moths is of little benefit. Eggs and young larvae that are leaf "mining" within the leaf are also not affected by an insecticide. The open feeding larvae are the best stage for control.

Action threshold for insecticide application (based on crop stands averaging 150 to 200 plants/m^2):

a) Insecticide application should be considered when plants are in the seedling or rosette stage and there is 25 to 33 per cent defoliation with larvae still present.
b) Immature and flowering fields: 100 to 150 larvae/m^2
c) Flowering and podded fields: 200 to 300 larvae/m^2

In areas where stands are thinner, the action threshold should be adjusted accordingly.

Diamondback moth larvae

Diamondback moth pupa

Diamondback moth adult

Bertha armyworm (*Mamestra configurata*) - Outbreaks of bertha armyworm tend to last two to three years in an area and occur every eight to 10 years. Parasites, viruses and fungal disease contribute to the end of an outbreak period.

Bertha armyworm overwinters in the pupal stage in the soil. The adult moths emerge about mid-June to mid-July depending on heat development in the spring. In late July and August larvae feed on vegetative parts of the plant; later feeding on the flowers and pods occurs during the last larval instars.

There is one generation of bertha armyworm per year. Newly hatched larvae are pale green. Larvae pass through six instars and may be in a variety of colour phases of green and pale brown. At maturity, larvae are large (4 to 6 cm long) velvety black caterpillars with a light brown head and a broad pale orange stripe along each side. It is the later instars that cause the majority of the damage. Larvae chew irregularly shaped holes in leaves, and will cause direct yield loss by chewing into pods and flowers.

Bertha armyworm moths can be monitored using pheromone traps that catch male moths. Trap numbers provide an indication of numbers of moths in an area prior to emergence of the damaging larval stage. An annual bertha armyworm monitoring program using pheromone traps is conducted by the Government of Saskatchewan each summer; weekly updates can be viewed at their website during the time of surveys (June-August) and final map results can be viewed throughout the rest of the year. Populations in Saskatchewan are apparently on the rise.

Scouting larval populations requires making counts at several locations in a field. At each location, mark out an area one metre square (m^2) and shake the plants growing within that area to dislodge the larvae. Count the number of larvae in the m^2 area, including any hiding under soil and leaf litter. Use the average number of larvae at the sites surveyed within each field to determine if the economic threshold has been exceeded and an insecticide is necessary. If an insecticide application is necessary, be aware of the pre-harvest interval associated with the product. Since bertha armyworm infestations commonly occur later in the season, it is important to adhere to restrictions to prevent excess residues that could affect export of the commodity. Application should be done later in the day to avoid negative impacts on pollinators. The following table indicates the economic thresholds for different combinations of expected seed value and spraying costs to be used as a guide (the information is adapted from research conducted on Argentine canola but can be applied to mustard due to the similarities between the two crops). For example, if the current seed value is $10/bu, and estimated spraying cost of the insecticide is $8/ac, then deciding to spray for bertha armyworm would make economic sense when there is an average of 14 larvae/m^2 or more.

Spraying Cost ($/ac)	Expected seed value ($/bushel)										
	6	7	8	9	10	11	12	13	14	15	16
	# larvae/m^2										
6	17	15	13	11	11	10	9	8	7	7	6
7	20	17	15	13	12	11	10	9	9	8	8
8	23	20	17	15	14	13	12	10	10	9	9
9	26	22	19	17	16	14	13	12	11	10	10
10	29	25	22	19	17	16	15	13	12	11	11
11	32	27	24	21	19	17	16	14	13	13	12
12	34	30	26	23	21	19	17	16	15	14	13

Adapted from Agriculture Canada, Alberta Agriculture, and British Columbia Ministry of Agriculture, Fisheries and Food; and Mason, P. G., Arthur, A. P., Olfert, O. O., & Erlandson, M. A. (1998). The bertha armyworm (*Mamestra configurata*) (*Lepidoptera: Noctuidae*) in western Canada. *The Canadian Entomologist*, 130(3), 321-336.

Bertha armyworm larva last instar and damage

Bertha armyworm moth

Cabbage seedpod weevil (*Ceutorhynchus obstrictus*) - The adult cabbage seedpod weevil is an invasive small, ash-grey beetle, 3 to 4 mm long. They are hard-bodied insects with a long snout. The larvae are white, grub-like organisms that feed within the seedpod of the host plants – cruciferous crops and weeds. The cabbage seedpod weevil distribution is primarily in southern Saskatchewan but working its way north. Originally entering Saskatchewan in 2000 in the southwest, it has expanded its range eastward and north into central regions.

There is one generation of cabbage seedpod weevils per year. They overwinter as adults and emerge in the spring migrating from weeds into host crops when temperatures increase and the plants begin to flower. Early in the season, they feed on vegetative growth. After mating, the females lay eggs in developing pods. After hatching, the larvae feed within the developing pod consuming seeds. At maturity, the larvae exit through the pod wall, dropping to the ground to pupate. This can allow entry for disease and may result in premature shattering of the pod. Later, the emerging adults will feed on the plants causing additional damage.

Only brown and oriental mustard varieties require monitoring and potentially insecticide control of the weevil. Yellow mustard (*Sinapis alba*) is considered resistant. A sweep net is required to estimate numbers of cabbage seedpod weevils in a field. Monitoring should begin at the early bud stage through the flowering stage. Choose 10 sites within each field and estimate the average number of weevils per sweep. An economic threshold of 25 to 40 weevils per 10 sweeps on average is recommended as a level at which control measures may be required. Infestations will be more concentrated in field margins early in the season. Control measures may only be needed in certain areas and not necessarily across

the field. An insecticide should be applied at about 10 to 20 per cent bloom. Application too early may result in reinvasion from overwintering sites. Insecticides should be applied later in the day to avoid pollinators and beneficial insects that are more active during the day.

Cabbage seedpod weevil

Other minor insects - Aphids, blister beetles, cabbage loopers, imported cabbageworms and occasionally grasshoppers.

Grasshopper

Diseases

The Brassicaceae family (formerly Cruciferaceae family) includes various *Brassica* species, representing oilseed, vegetable and fodder crops. Brown mustard and oriental mustard (*Brassica juncea*) are members of this genus. In the same family but a different genus are yellow mustard (*Sinapis alba*) and wild mustard (*Sinapis arvensis*). Because of their close relationship, plants in this family are often susceptible to the same diseases. The following is an outline of diseases of crucifers with comments on the potential for disease in mustard (*Sinapis alba* and/or *Brassica juncea*).

Damping-off, Wirestem, and Brown Girdling Root Rot

Pathogen(s): Damping off - *Phytophthora cactorum* and/or *Pythium* spp.
Wirestem and brown girdling root rot - *Rhizoctonia solani*

Host range: Seedling diseases including damping-off, seedling blight, wirestem, and root rot affect *Brassica* and other plant species including pulses and flax.

Risk: High

Symptoms: Watch for seeds that fail to germinate or fail to emerge, and roots that turn brown or seedlings that turn yellow, shrivel and decay, particularly at the stem base.

Damping off symptoms on canola

Alternaria Diseases (Black spot, Gray Leaf Spot, Pod Spot)

Pathogens: *Alternaria brassicae* and/or *Alternaria brassicola*
Host Range: Most of the economically important vegetable, oilseed, forage, and condiment brassicas, and many wild and weedy crucifers.
Risk: High
Symptoms: Watch for gray to purple to black small spots or lesions that may expand into concentric zones surrounded by a yellow halo.

Alternaria leaf lesion surrounded by chlorosis on canola

Aster Yellows

Pathogen: Aster Yellows Phytoplasma
Host Ranges: Most of the economically important vegetable, oilseed, forage, and condiment brassicas, and many wild and weedy crucifers.
Risk: High
Symptoms: Watch for blue-green discoloured plants, with leaves developing a red or purple tinge. Malformed flowers and may produce sterile, green leaf-like structures, and pods are replaced by round or oval blue-green hollow, flattened bladder-like structures. Infected plants may become woody and are often taller than the rest of the crop canopy.

Aster yellow symptoms on canola

Sclerotinia White Mould

Pathogen: *Sclerotinia sclerotiorum*

Host Range: Extremely wide host range among dicots, including crucifers, and other important broadleaf crops and weeds.

Risk: High

Symptoms: Watch for soft, water-soaked white to gray lesions on leaves and stems. Plant parts above the affected area may turn pale green or yellow, wilt and die. Mature lesions will become bleached shred easily, resulting in premature ripening and lodging. White mould may grow on rotting stems and sclerotia may be evident inside infected stems.

Sclerotinia infection of a canola stem with sclerotia inside the infected stem

Downy Mildew

Pathogen: *Hyaloperonospora parasitica*

Host Range: Common on cabbage, Brussels sprouts, cauliflower, broccoli, kale, and kohlrabi; Chinese cabbage, turnip, and turnip rape; oilseed rape and rutabaga; brown mustard and oriental mustard; black mustard and Abyssinian mustard. Many other crucifers including yellow mustard and wild mustard area also likely hosts.

Risk: Medium

Symptoms: Watch for a mealy growth on the underside of the leaf, corresponding to yellowing of the upper surface of the leaf.

Downy mildew lesions on the underside of a canola leaf

White Rust

Pathogen: *Albugo candida*

Host Range: Common on *B. oleracea, B. rapa, B. juncea* (brown mustard and oriental mustard), *B. nigra* (black mustard), and *B. carinata* (Abyssinian mustard). Radish, horseradish, wild mustard, shepherd's purse, and other weedy species are also likely to be infected.

Risk: Medium

Symptoms: Watch for white pustules and "staghead" deformation of flowering stems and pods.

Staghead deformation and white pustules associated with white rust on canola

White rust symptoms on the upper surface of an infected brown mustard leaf (Photo by Lawrence Barany)

Powdery white pustules on the lower surface of a brown mustard leaf infected by *Albugo candida* (Photo by Lawrence Barany)

White Leaf Spot and Gray Stem

Pathogen: *Mycosphaerella capsellae*

Host Range: Wide range of crucifers, including canola, mustards and a variety of cruciferous weeds.

Risk: Medium

Symptoms: Watch for white to gray leaf spots that may spread to give an overall gray appearance to plants.

Clubroot

Pathogen: *Plasmodiophora brassicae*

Host Range: Cruciferous field crops such as canola, mustard (all types), camelina, oilseed radish and taramira; as well as cruciferous weeds (e.g. stinkweed, shepherd's purse, wild mustard) and vegetables.

Risk: Medium (risk increases when mustard is grown in known clubroot infested areas and environmental conditions favour clubroot disease development)

Symptoms: Watch for suspicious stunting, wilting, yellowing and premature ripening. Check the roots for clubroot galls.
More information about clubroot can be found here.

Clubroot galls on mustard roots

Blackleg

Pathogen: *Phoma lingam, Leptosphaeria* maculans and/or Leptosphaeria *biglobosa*

Host Range: Economically important on a variety of brassica crops, but those with the B genome, including *B. juncea*, *B. carinata*, and *B. nigra* are more resistant than other *Brassica* species. Can occur on *Sinapis* spp.

Risk: Low – Risk can increase when the plant is wounded

Symptoms: Watch for round to irregularly shaped dirty white lesions on the leaves and white or gray lesions with a dark border on stems or points of leaf attachment. Stem lesions may also appear as a general blackening or dry rot inside the stem base. Blackleg lesions are usually dotted with numerous tiny round specks (pycnidia).

Blackleg lesion on a canola leaf

Blackleg stem lesion on a canola stem

Fusarium Wilt

Pathogen: *Fusarium oxysporum* and/or *Fusarium avenaceum*

Host Range: Cabbage is the most significant host crop, but also infects other brassica crops including canola and mustards.

Risk: Low

Symptoms: Watch for wilting, stunting, and yellowing, with yellow or red discolouration at the stem base, and development of symptoms on only one side of stems.

Fusarium wilt symptoms on a canola plant

Verticilium Wilt

Pathogen: *Verticillium longisporum*

Host Range: Severe symptoms in oilseed rape and certain other *Brassica* species, and wild mustard. No information on yellow and brown mustard. Non-cruciferous hosts may also be infected but economic damage not reported.

Risk: Low

Symptoms: Watch for wilting, stunting, and yellowing, with yellow or red discolouration at the stem base, and development of symptoms on only one side of stems, in addition to shredding of the epidermis containing tiny black microsclerotia.

Disease scouting

Mustard has not traditionally been a crop with major disease issues for Saskatchewan growers. However, the potential for disease is influenced by the crop rotation, pathogen population and weather conditions. Therefore, scouting for disease is important to:

- Accurately identify disease symptoms before the disease becomes well-established in mustard and economic losses occur; and
- Determine the effectiveness of integrated pest management strategies.

If the field is less than 100 acres, check a minimum of five sites and if the field is greater than 100 acres, check a minimum of 10 sites. Be most diligent scouting fields at greater risk to disease that include:

- Fields that were planted to infected or poor quality seed;
- Fields that have a short crop rotation (including canola or mustard) or are adjacent to infested crop residue from the previous season; and
- Fields that were planted to a susceptible crop variety.

In addition, check for areas in the field that are potential hot spots for disease development:

- Areas of the crop that may be heavier seeded or have increased fertility (e.g. headlands);
- Areas where moisture may have accumulated (e.g. hollows or near fence lines); and
- Areas where plants received damage from wind-blasting, drought, herbicide injury, frost, hail or other stresses.

Symptoms may occur in patches, be limited to field edges or be scattered across the whole field. That is why it is important to determine the full extent of the problem by scouting the entire field. Watch for discoloured plants and/or small discoloured spots on the leaves. Stop at each site and look down within the crop canopy, remove some plants and closely inspect the leaves and roots. Inspect both the top and bottom of leaves. Use a magnifying glass to help distinguish small spots and to look for tiny chew marks or shredding, which could indicate damage caused by insects. Remember to rub small spots with your thumb—if they come off easily, they likely are not disease. Inspect the roots. Root rot usually results in stunted growth and the plants may be light green, yellow, or brown in colour. Plants with root rot will pull easily from the soil. Look for lesions on the crown region or on roots. Also examine roots for swelling and the presence of clubroot galls which may appear as rotten or decomposing root tissue later in the growing season.

Other factors can cause symptoms that may be mistaken for disease. Problems can be diagnosed or eliminated depending on the pattern of symptoms in the field. Linear and/or repetitive symptoms that are not spreading are more likely to be related to an abiotic factor (non-living), mechanical patterns (seeding, old swath row) or overlap/miss of a chemical application. Widespread/even damage is often related to environmental stress and may include dry soils, waterlogged soils, high temperatures, frost, hail and strong winds causing sandblasting. Record weather events on a calendar for future reference, and scout fields within two days following an extreme environmental occurrence to determine the effects on the crop. Random symptoms or focal points that appear to be spreading are more likely related to disease, and may have been introduced by seed, soil-borne pathogens, airborne spores, or

insect vectors. However, herbicide residues and nutrient deficiencies may also be random, and if the focal point is related to a high or low spot in the field, symptoms may be due to stress.

Disease management

Crop rotation – Plant pathogens may survive in soil or on crop residues, as well as in living vectors such as annual plants, seeds and insects. Growing a variety of crops in the rotation allows time for pathogens that survive on crop residues and in soil to break down, which reduces the risk to subsequent susceptible crops. Although crop residues from pulses break down quicker than canola and mustard, both tend to persist and support pathogens longer than cereal crop residues. Therefore, in general, broadleaf crops require longer rotations to reduce the risk of disease.

Seed treatments – There are several seed treatments available to control seed rot, damping-off, seedling blight, and early season root rot caused by *Rhizoctonia, Pythium,* and *Alternaria* spp. However, currently all products registered are available to commercial seed treaters only.

Fungicides

There are three foliar fungicides registered for disease control in mustard (*Headline EC, Priaxor,* and *Lance WDG*), and two fungicides registered for use only on oriental mustard (*Cotegra* and *Proline 480SC*). *Lance AG* is a co-pack of *Lance WDG* and *Headline EC.* The diseases controlled by each of the registered foliar fungicides are indicated in the following table. For current information please see the Saskatchewan Agriculture Guide to Crop Protection.

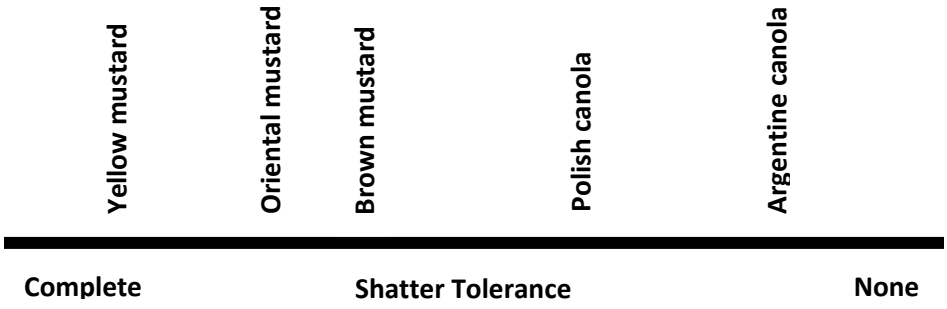
Product	Diseases
Cotegra	Control of sclerotinia stem rot (*Sclerotinia sclerotiorum)*
Headline EC	Control of black spot (*Alternaria brassicae*, *A. raphani*), and blackleg (*Leptosphaeria maculans*)
Lance AG	Control of sclerotinia stem rot (*Sclerotinia sclerotiorum*) and black spot (*Alternaria brassicae* and *A. raphani*)
Lance WDG	Control of sclerotinia stem rot (*Sclerotinia sclerotiorum*) and black spot (*Alternaria brassicae* and *A. raphani*)
Priaxor	Control of blackleg (*Leptosphaeria maculans*) and black spot (*Alternaria brassicae*, *A. raphani*). Suppression of sclerotinia stem rot (*Sclerotinia sclerotiorum*)
Proline 480 SC/Holdfast/Soratel	Control of sclerotinia stem rot (*Sclerotinia sclerotiorum*) in oriental mustard and carinata.

Harvest, storage and grading

Swathing vs straight combining

Mustards are relatively resistant to pod shattering and straight combining is often the preferred harvest method. However, swathing may be beneficial in some situations depending on evenness, stage of maturity and crop height.

Shatter tolerance makes straight combining a viable option for mustards; with yellow mustard having the highest level of shatter tolerance and all mustards being more tolerant than canola (both Polish and Argentine canola). Shatter tolerance will allow the crop to be straight combined when plants are mature with little loss of seed during combining. For crops with low levels of shatter tolerance, swathing is the preferred harvest method. The shatter tolerance of different Brassica crops is illustrated below.



When deciding between straight combining and swathing, the evenness of the crop should be taken into consideration. Evenness of the crop refers to the range of relative maturity. In many fields, there will be a range of maturity with low-lying spots maturing earlier. For uneven crops, swathing can be used to force the fields to ripen consistently. If straight combining is used and harvest is delayed until all plants are the optimum level of maturity, the risk of pod shattering and harvest loss increases. If fields with a range of maturity are straight combined too early, green seed levels will increase which could result in downgrading and increased moisture content of the grain.

Stage of maturity should also be considered when deciding which harvest method to use. If the crop is overripe, straight combining will be preferred and will result in less shatter losses than swathing. Maturity should be monitored closely since hot dry conditions can cause the crop to mature and dry down quickly.

Time of swathing

Timing of swathing is very important and should begin when the majority of seeds are at less than 25 per cent moisture. At this time, seeds will feel firm when pressed between the thumb and forefinger. Some of the pods will have a purplish tinge; the lower pods will have started to change colour while the upper pods will remain green. It is important not to rely solely on pod colour change. Open the pods and look for seed colour change. For yellow and oriental mustard, swathing should occur when 75 per cent

of the seeds have changed from green to yellow. For brown mustard, optimal swathing timing is when 60 per cent of seeds have changed from green to brownish or red.

During swathing, the mustard plants should be cut just below the lowest pods. This will provide stubble to anchor the windrow and prevent the swath from blowing. To ensure adequate anchoring, a swath roller should be used to compact the swath to minimize wind damage and loss. The roller should be set to ensure firm packing but care must be taken to avoid shattering of overripe pods due to over packing, which will also reduce drying.

The environmental conditions while the crop is in the swath will influence the number of green seeds. The moisture content should be above 20 per cent and the ambient temperature must be above 5˚C while colour change is occurring in order to reduce greed seed. Extreme high temperatures or frost shortly after swathing can destroy the enzymes required to remove green seed colour and will prevent colour change which could result in downgrading.

Straight combining

Straight cutting is beneficial when mustard is uniformly mature and has a low green seed content or if the crop is too short to properly anchor a swath. Harvest should occur when moisture levels are around nine per cent. When combining, set the reel speed at approximately the same speed as the ground speed to help prevent shattering. The header height should be just below the lowest pod to minimize the amount of stem or weed tissue processed through the combine. As mentioned for swathing, green seed content can be reduced in the crop as long as the seed moisture is above 20 per cent and the ambient temperature is higher than 5˚C. However, early fall frost while the crop is still green will kill the enzymes required for colour change, resulting in higher green seed content.

Desiccation

Desiccation is not commonly used for mustard. Application of a desiccant will provide accelerated plant dry down of green tissues in the canopy but will **not** hasten maturity. Desiccants registered for use on mustards contain either diquat (*Reglone*, *Reglone Ion*, *Desica*, Armory 240, Advantage Diquat 240, Clone, Dessicash Desiccant, Co-op Bolster II, IPCO Bolster II, Stage, Drifast and *Craven*). Desiccation offers the advantage of terminating any remaining green growth of pods and stems as well as drying down green weeds present in the field. If a desiccant is applied, it should occur at the same recommended timing for swathing, at approximately 75 per cent seed colour change for diquat products.

Please note: At the time of printing (2022), BASF has not fully established import tolerances (maximum residue limit (MRLS)) for mustard for all markets around the world. Because this crop is heavily exported and some exports are made to markets where these MRLs have not been established, **BASF does not recommend the use of HEAT LQ as a harvest aid on mustard for the 2022 season.

Pre-harvest weed control can be effective for controlling perennial weeds that are present late in the season and were not controlled with in-crop herbicide applications. *RoundUp WeatherMax* is the only

herbicide registered for pre-harvest weed control in mustard. It is important to note that this product is not registered to be used as a desiccant and because of the different mode of action it will not result in accelerated plant dry down as seen with desiccants.

For complete and detailed information on desiccation timing, rates and pre-harvest intervals, refer to the registered product label recommendations and the Saskatchewan Agriculture Guide to Crop Protection.

Harvesting

Mustard should be combined when the moisture content has dropped to around nine per cent, when most seeds are mature and green seed content is low.

Depending on the condition of the crop, the cylinder speed should be between 400 and 800 rpm or at a speed where the number of cracked seeds is acceptable. Over-threshing at the cylinder or concave is a common problem that will result in cracked seeds, high dockage and loading the shoe with broken stems and pods. To keep the number of unthreshed and broken stems to a minimum, the concave clearance should be wider in the front, up to 25 mm (1 inch), and narrower, 3 to 13 mm (1/8 to 1/2 inch) at the back.

For mustard, the cleaning action depends more on shaking separation than wind separation. As a result, the fan speed should be set to approximately three-quarters the speed used for wheat. The air volume should just be adequate to move the material evenly across the sieves and the speed of the shaker should be increased by an additional 10 per cent (if possible).

The top sieve, or chaffer setting should be 6 mm to 10 mm (1/4 to 1/3 inch) and the lower sieve setting should be 3 to 6 mm (1/8 to 1/4 inch). The sieves should be adjusted to control the amount of trash in the hopper. If there is excessive trash, the sieves are open too much and if the sample is perfectly clean the sieves can be opened a bit.

Storage

Mustard is considered to be dry at 9.5 per cent seed moisture. For safe, long-term storage the seed should be at nine per cent moisture. If the moisture of the grain is between 9.5 and 15 per cent, drying is recommended to ensure safe, long-term seed storage. When moisture is greater than 15 per cent, the drying should occur in two stages. The grain should be first dried down to 13 per cent moisture and allowed to cool to the outside temperatures. The grain can then be dried down to nine per cent and allowed to cool before being placed in the bin. Drying should not exceed 65˚C (150˚F) air temperature or 45˚C seed temperature. It is important to remember that mustard seed is denser than cereal seed and that it will require two to three times more static pressure to force the air through the crop.

Aeration is used to change the temperature of the grain in storage and reduce moisture levels. Aeration should begin when the grain first enters the bin and continue until the grain is near the temperature of the outside air. When the outside temperature has cooled by 5 to 10˚C, the mustard should be cooled again. Mustard should be stored below 18˚C and, for safe storage, should be kept as cool as possible.

When first placed in the bin, the seed will still have a relatively high respiration rate for up to six weeks. Heat and moisture, byproducts of respiration, will increase the risk of spoilage. Hot spots can spread rapidly throughout the bin making frequent monitoring very important – especially in those first six weeks. The grain at the bottom of the bin will dry first and will have a slightly lower moisture content. For safe storage, it is important to not only monitor stored mustard frequently but also to check different areas of the bin for temperature and moisture conditions. If possible, turn at least 1/3 of the bulk in the bin to minimize risk of spoilage from initiating.

The amount of dockage will also influence the risk of spoilage. Dockage can raise the moisture content of the grain to result in heating & moulding; if possible, it should be removed prior to long term storage. Additional tips and research about monitoring grain temperature and preventing spoilage can be found on the Canadian Grain Commission's website.

Storage insects

As an oilseed, mustard does not have frequent problems with insect pests in storage. Most commonly, insects observed in stored mustard are related to poor storage conditions and fungal growth associated with moist conditions.

Pscocids (a.k.a. book lice) are an example of fungus-feeding insects. Although not damaging to the commodity itself, they are an indication of fungal growth. Cooling and bringing down the moisture level in the storage bin will stop the fungal growth and in turn eliminate the fungal-feeding insects.

Grading

The standards for mustard quality are set by the Canadian Grain Commission. The same primary and export grade determinants are used for all three mustard types. The only exception is that there is no inconspicuous admixture percentage for yellow mustard like there is for brown and oriental mustards. Inconspicuous admixture includes any seeds such as canola, common wild mustard seed or any other seeds that blend with oriental or brown mustard and cannot be readily identified. In the table below, the term "Other Classes" refers to the presence of other types of mustard or *Brassica carinata* in the sample that are not the mustard type being graded. Total damage is the maximum per cent of damaged seed allowed and includes seeds that are distinctly shriveled, badly discoloured from mould, completely and densely covered with rime or dried white mucilage, are excessively weathered, sprouted, distinctly green, heated or otherwise damaged.

Grade Name	Standard of Quality		Damage (%)		
	Degree of Soundness	Other Classes (%)	Distinctly Green	Heated	Total
No. 1 Canada	Reasonably well-matured, sweet, good natural colour	0.5	1.5	0.1	1.5
No. 2 Canada	Fairly well-matured, sweet, reasonably good colour	2	2	0.2	3

No. 3 Canada	May have the natural odour associated with low quality seed, not any odour that would indicate serious deterioration	5	3.5	0.5	5
No. 4 Canada	May have the natural odour associated with low quality seed, not any odour that would indicate serious deterioration	10	3.5	1	10

Grade Name	Inconspicuous admixture ** (%)	Conspicuous inseparable seeds					Other (%)			
		Distinctly detrimental (%)				Total (%)				
		Cow cockle	Sclerotinia	Wild mustard Canola/ rapeseed	Total distinctly detrimental		Ergot	Excreta*	Soft earth pellets	Stones
No. 1 Canada	1	0.1	0.1	0.1	0.1	0.3	0.05	1K	0.01	0.05
No. 2 Canada	1	0.2	0.2	0.2	0.2	0.5	0.05	1K	0.2	0.05
No. 3 Canada	1	0.3	0.3	0.3	0.3	0.7	0.05	1K	0.3	0.05
No. 4 Canada	1	1	1	1	1	3	0.05	0.005	1	0.1

*Number of kernel-sized pieces in 500 g
**Not a grading factor for yellow mustard
Source: Canadian Grain Commission

Green seed

Green seeds are immature seed that contain the pigment chlorophyll which can give an off-colour to finished products. Under adequate environmental conditions, chlorophyll will be converted to other compounds by three enzymes as part of the natural maturing process, and thus lose the green colour associated with the chlorophyll. The required enzymes are only active when seed moisture is greater than 20 per cent and if the ambient temperature is above 5˚C. As a result, frost prior to harvest or severe heat after swathing will destroy those enzymes, causing the green colour to be locked in the seed, since under those circumstances the chlorophyll will not be degraded as it would with the normal maturation process. Green seed will only diminish in the plant when the enzymes are active; it will not be further reduced in the bin if those enzymes are no longer active.

Heated seed

Heating of the grain may be caused by excessive moisture and/or high temperature during storage. Due to the higher oil content, mustard must be stored at a lower per cent moisture than cereals. The moisture will be concentrated in the meal portion of the seed making overall moisture levels appear low, but it is important to remember that all of the moisture will be concentrated in half of the seed. Mustard stored long-term should be at less than nine per cent moisture and less than 20˚C to prevent heating. The moisture levels of the grain will increase by approximately one per cent when first placed in the bin due to a sweating period caused by respiration of the seed.

Sclerotinia sclerotia

Sclerotinia sclerotiorum causes disease in mustard, canola, sunflower, flax, pulse crops and many broadleaf weed species. The disease-causing fungus produces hard black resting bodies (sclerotia) in or on the stems of infected plants. During harvest, the sclerotia can be threshed out and end up in the seed. Downgrading will occur even when low levels of infestation are present.

Ergot

Ergot is a disease of cereals and grasses that will not infect mustard or other broadleaf crops. The fungus that causes ergot also produces sclerotia similar to sclerotinia. There is a low tolerance for ergot in grain because the sclerotia contain a mycotoxin.

Ergot infestation of mustard grain can occur if there are infected cereal volunteers or weeds in the crop or contaminated harvesting and transportation equipment or storage facilities.

Excreta

Excreta are the droppings of rodents and insects, and contamination is often due to unclean harvest, storage or transportation equipment. Inadequate facilities will allow access to rodents and result in excreta contamination. Good quality mustard has no tolerance for excreta.

Rime

Yellow mustard has a mucilage that surrounds the seed coat that has desirable water binding properties. With repeated wetting and drying of the seed, the mucilage will flake off and the seed will be covered in a white substance known as rime. Though rime is not graded by the Canadian Grain Commission, it is a downgrading factor for yellow mustard at the buyer and processor level.