5/Weed Control

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Weed Control Contents

Introduction 5.3

Weed Identification 5.3

Table 5.1 Characteristics of some common weeds in pulse crops
Table 5.2 Abundance of the 10 most common weeds in lentil fields and their abundance in other crops in the Dark Brown soil zone in Saskatchewan
Table 5.3 Abundance of the 10 most common weeds in pea fields and their abundance in other crops in the Black soil zone in Saskatchewan
Table 5.4 Herbicide resistant weeds in Saskatchewan and Manitoba
Table 5.5 Yield loss in pulse crops caused by weeds
Figure 5.1 Wild tomato
Figure 5.2 Round leaf mallow

Weed Prevention 5.6

Sound Agronomy for Weed Management 5.8

Tillage 5.9

Herbicide Use 5.10

Other Herbicide Practices 5.15

Know When to Treat 5.15

Biological Control 5.16

Appendix 5.17

Table 5.6 Herbicides currently registered for use in pulses

Weed Control

Introduction

Weeds are a challenging problem to pulse crop producers. Simple, inexpensive herbicide solutions, as used in cereal production, are not as available in pulse crops. Pulse crops are weak competitors with weeds because of their slow seedling growth, low stature, and their failure to effectively close the crop canopy until late in development. Limited herbicide choices, the increased annual and perennial weed densities in extended rotations, volunteer crops as weeds, and the increased importance of winter annuals and secondary weed competitors present special weed control challenges to the pulse grower.

Effective, integrated weed management begins long before seeding. Integrating weed management means considering how all aspects of the farm operation work together, and how they influence the weeds in a given field.

To be truly effective, the farmer needs to:

• Know the weeds and prevent problems.

• Practice sound agronomy in growing the crop.

• Have practical herbicide or cultivation techniques available.

• And know when to use them.

A producer must always determine if a weed problem is of economic concern, or only an appearance problem, before selecting a weed control method.

Good, integrated weed management reduces the need to use herbicides in crop and should keep weeds in check. Herbicides are normally needed to maximize pulse production and even to make it profitable.

Weed Identification

Good weed management begins with knowing what weeds are present.

• Fields should be inspected repeatedly during the growing season.

Which weed species are present? How many are there? Are they widespread, or in localized pockets? How big are they compared to the crop? Is the crop reduced around them? When did they emerge? How rapidly are they growing? Are they annual, biennial or perennial? How are they spreading? What changes have occurred since last year?

Several good guides to weed identification are available through

Weed	Germination	Maturity	Dormancy
Wild oat	Early and throughout	Medium	Long
Green foxtail	In warm soil	Mid to late season	Short to medium
Wild buckwheat	Early	Mid to late season	Medium
Russian thistle	Early	Mid to late season	Medium
Stinkweed	Fall and early spring	Early	Medium to long
Shepherd's purse	Fall and early spring	Early	Medium to long
Flixweed	Fall and early spring	Early	Medium
Lamb's quarters	Early	Late	Long
Canada thistle	Medium	Late	Medium
Redroot pigweed	In warm soil	Late	Long
Wild mustard	Early and throughout	Early to late season	Very long

Table 5.1 *Characteristics of some common weeds in pulse crops.*

Table 5.2 *Abundance of the 10 most common weeds in lentil fields and their abundance in other crops in the Dark Brown soil zone in Saskatchewan.*

	Lentil fields		Cereal, oilseed fields	
	Frequency	Number	Frequency	Number
	(%) of fields	/ m²	(%) of fields	/ m²
Wild oat	75	3	67	8
Wild buckwheat	69	4	61	4
Green foxtail	50	24	60	20
Canada thistle	44	3	32	2
Redroot pigweed	31	2	27	2
Russian thistle	31	3	27	3
Thyme-leaved spurge	31	8	12	5
Vol. spring wheat	31	2	19	1
Wild mustard	31	3	18	4
Stinkweed	25	3	48	6

Source *1995 Saskatchewan Weed Survey, Thomas, Frick and Juras, with some recalculation.*

Table 5.3 *Abundance of the 10 most common weeds in pea fields and their abundance in other crops in the Black soil zone in Saskatchewan.*

	Pea Fields		Cereal, oilseed fields	
	Frequency	Number	Frequency	Number
	(%) of fields	/ m²	(%) of fields	/ m²
Canada thistle	77	2	66	3
Perennial sow thistle	73	2	50	3
Wild oat	73	7	64	8
Wild buckwheat	64	2	72	3
Green foxtail	46	4	64	12
Shepherd's purse	46	6	25	3
Wild mustard	46	2	30	3
Lamb's quarters	41	2	39	3
Stinkweed	41	6	45	6
Quackgrass	32	7	16	8

Source *1995 Saskatchewan Weed Survey, Thomas, Frick and Juras, with some recalculation.*

Saskatchewan Agriculture and Food, Alberta Agriculture, Agriculture and Agri-Food Canada, University of Saskatchewan, and extension agrologists. Some of these include detailed information about and pictures of each weed. Table 5.1 includes some information on the most common weeds.

The weeds most commonly found in pulse crops are common in cereals and oilseeds as well (Tables 5.2 and 5.3). If a record has been kept of the weeds in a field over the past 3 to 5 years, it should indicate which weeds to expect in the coming year.

All farm management practices affect weeds and weed communities. Within weed communities, the species often change. For instance, the use of phenoxy herbicides, such as 2,4-D, has significantly reduced the populations of wild mustard in cereal crops. Other weeds, such as wild buckwheat, are not controlled by this herbicide. Herbicides may actually benefit weeds that are not killed because the surviving weeds no longer have to compete with the other weeds.

A great deal of variability occurs within a weed species. Because of genetic variability, some individuals survive when most others are killed. If a particular weed management practice is continued, it results in an increase in the proportion of the survivors, making that weed management practice less effective. Herbicide resistant weeds are a good example of this. Repeated use of a given product, or products with similar chemistry (and similar ways of killing weeds), has resulted in weeds that are not controlled by that group of chemicals. Such weed resistance to herbicides has been identified in Saskatchewan (Table 5.4).

• Avoiding repeated use of the same chemical, or chemicals in the same group, will reduce the likelihood of developing herbicide resistance within a weed population.

Other management factors also influence weeds. Repeated use of delayed seeding following tillage favours late germinating weeds, such as redroot pigweed and green foxtail, over early germinating weeds, such as wild oat and wild buckwheat. Repeated fall tillage favours weeds that germinate in the spring over those that germinate in the fall, and so on. In this way, each practice becomes less effective as it is used repeatedly. Varying manage-

Table 5.4 *Herbicide resistant weeds in Saskatchewan and Manitoba.*

Source *Saskatchewan Agriculture and Food, Guide to Crop Protection 1999.*

Weed	Description of resistance
Wild oat	Typically resistant to 10 or more times normal field rates of Group 1 herbicides*.
Wild oat	Resistant to Group 2 herbicides.
Wild oat	Resistant to 1.5 to 4 times field rates of Group 3 herbicides. At present,
	confirmed in Manitoba.
Wild oat	Resistant to 2 to 5 times field rates of herbicides in Group 1, 2 and 8.
	At present, confirmed in Manitoba.
Green foxtail	Resistant to 5 or more times field rates of Group 3 herbicides.
Green foxtail	Resistant to 10 or more times field rates of Group 1 herbicides.
Green foxtail	Resistant to herbicides in both Groups 1 and 3.
Wild mustard	Resistant to 10 or more times field rates of herbicides in Group 4.
	At present, confirmed in Manitoba.
Wild mustard	Resistant to approximately 5 times field rates of herbicides in Group 5.
	At present, confirmed in Manitoba.
Kochia, wild mustard, chickweed, hemp nettle, Russian thistle	
	Resistant to 10 or more times the field rates of Group 2 herbicides.
	Wild mustard, chickweed and hemp nettle confirmed in Manitoba.
	Russian thistle confirmed in Saskatchewan

**Herbicides in each group are listed in the Guide to Crop Protection.*

ment practices can prevent the buildup of a given weed type by not allowing it a consistent advantage. A diverse crop rotation can include both summer and winter crops, annual and perennial crops, grassy and broadleaved crops, and crops with different heights, leafiness, and competitive ability. In addition, the crops can be sown early some years and late in others. The herbicides can be rotated. The timing and method of application of fertilizer, timing of tillage, timing of harvest, and the post-harvest treatments can also be varied. Growing different crops in different years allows for varied management in many areas.

Factors, such as heat, drought, flooding, hail and frost, also have an effect on weeds, but are beyond the grower's control. Their impact on crops and weed control practices should be noted in determining what weed pressures to expect in following years.

Weeds respond to competition around them. In traditional cereal crops and in weedy fields, competition from the crop and other weeds has a major impact on the shorter and less competitive weeds. If competitive weeds are significantly reduced in a non-competitive crop (pulses), the field is wide open for less competitive weeds. This has happened in some lentil growing areas, where weeds such as cow cockle, roundleaf mallow, bluebur, and wild tomato, have became a serious problem. These weeds are not new, but they do not compete well with taller wheat, wild oat, and wild mustard plants. Once these competitive species are removed from the field, wild tomato can become a problem.

Weeds can have a major impact on yield and must be

Table 5.5 *Yield loss in pulse crops caused by weeds.*

Weed	Weeds/m²	Crop loss (%)	Crop	Location
Wild mustard	14	45 – 55	Navy bean	Morden
Wild mustard	14	2 – 35	Pea	Morden
Hairy nightshade	14	45 – 80	Pinto bean	Lethbridge (irrigated)
Redroot pigweed	11 – 14	70 – 85	Pinto bean	Lethbridge (irrigated)
Lamb's quarters	14 – 32	70 – 85	Pinto bean	Lethbridge (irrigated)
Wild oat	105	74	Lentil	Saskatoon
Green foxtail	210	24 – 34	Lentil	Indian Head
Wild tomato	336	62	Lentil	Vonda

taken seriously. Lentil, dry bean, and chickpea plants are short and rarely form a thick, closed crop canopy. As a result, these crops are weak competitors. Pea has slow early development, and is also a weak competitor. Yield losses, due to weed competition, depend on the type and number of weeds, the growing conditions, and the time of emergence of the crop and weeds. Losses can be severe (Table 5.5) and may make production unprofitable.

Research in Alberta emphasizes the importance of early weed control. Yield losses from weeds increased rapidly, if the weeds were not controlled within two weeks of emergence of the pea crop.

Pulse crops are susceptible to weed problems that may not be important in other crops. Weeds that remain green late in the season can add to the difficulty of harvest. Wild tomato (Figure 5.1) and round-leaf mallow (Figure 5.2) are low-growing weeds that might not be of concern in a wheat or barley crop, but can cause both a yield loss and a significant increase in harvest difficulty in crops, such as lentil, that are harvested very close to the ground.

Weeds with juicy fruits that can be crushed during threshing, like wild tomato, can stain pulse seeds and increase earth tag. Pulse seeds are very susceptible to mechanical damage and the cleaning out of weed seeds may cause further quality losses.

New weed problems do arise. Hairy nightshade is a newly introduced and serious weed problem where dry bean is grown under irrigation. In Alberta, up to 30% of the dry bean fields are "infested" and yield losses range up to 75%. It is not common yet in Saskatchewan, but it may spread as bean acreage under irrigation increases.

Source *Pulse Production Manual 1997*

Figure 5.1 *Wild Tomato.*

Source *Pulse Production Manual 1997*

Figure 5.2 *Round Leaf Mallow.*

Weed Prevention

The old saying that "an ounce of prevention is worth a pound of cure" is certainly true in weed management. In growing pulse crops, the two main preventative techniques are to prevent new problems, and to produce pulses where old problems are under control.

• The use of clean seed is an effective means of avoiding the introduction of new weed species into your fields.

This is especially important when introducing a crop from regions that may have weeds that are not present in your area. Special care should be taken to avoid the introduction of wild tomato and other members of the nightshade family. The seeds of this weed can stick to pulse seeds and, since the fruits can be similar in size to pulses, they may not be removed by standard cleaning procedures. This weed can make short crops nearly un-harvestable. The use of Certified seed of recommended varieties ensures that the seed will be of known quality and relatively free from weed seed contamination and seed-borne diseases. These factors are important in the establishment of a vigourous crop.

Combines and other equipment can easily introduce weeds into a field, if they are not thoroughly

cleaned between fields. Custom combine operators can easily introduce weeds into a field as they travel over large distances and may not clean equipment between fields. Road maintenance also has the potential to bring in weed seeds with the gravel used in resurfacing. New weeds are often introduced in small numbers. If the grower is inspecting the field regularly, the weeds can be more quickly noticed and removed. Hand weeding or spot spraying may be the most cost-effective technique for preventing establishment of rare, but potentially problematic weeds, such as hairy nightshade.

It is also important to avoid introducing weed problems into a given field from other areas of the farm. Growers can reduce the movement of weeds within the farm, if they control weeds before they set seed, and avoid weedy patches with equipment. Wild tomato and round-leaved mallow are common around abandoned barns and farmyards. Scentless chamomile is often found around sloughs and in less disturbed sites before it is found in crop fields. Shelterbelts often harbour plants with wind-dispersed seeds, such as sow-thistle, groundsel, and various types of tumbleweed, including kochia and Russian thistle. Feeding cattle with straw or hay from other areas and spreading the manure can introduce weeds.

When a weed problem exists in a small area of a field, it can be readily spread by farm equipment. Harvesting through a wild tomato patch, for instance, will throw the seeds and fruits of wild tomato through the combine. Some seeds adhere to the combine and are spread from the combine to other parts of the field (or even the next field). Cultivating through a quackgrass patch picks up rhizomes and transplants them throughout the field. Weeds can be contained within a small manageable area if the areas are worked separately and the equipment is thoroughly cleaned afterward.

Chaff management can also have an impact on the weediness of fields in succeeding years. Weed seeds can be very effectively spread through the combine with the chaff, particularly when using a chaff spreader to help improve residue management. Cereal and oilseeds that pass through the combine can also be a source of difficulty as they produce volunteers in following crops. Collection of chaff will reduce weed seed numbers and eliminate chaff rows that can interfere with seed placement and germination. The chaff makes a valuable livestock feed.

Field selection is an important consideration.

• It is wise to avoid sowing pulses in very weedy fields; fields with nightshades, such as wild tomato; or fields with perennial broadleaf weeds, such as Canada thistle and sow thistle.

These weeds are easier to manage in other years of the crop rotation. Growing strongly competitive crops, such as barley, and using grazing, mowing, and tillage appropriately can reduce these problems before a pulse is grown on a given field. If a pulse is grown in a planned rotation, herbicides not available in the pulse year may be used in the preceding year(s). Effective weed management requires the consideration of several years at once. For instance, a pre-harvest desiccant or pre-harvest herbicide may be more economical in the long run, if the following crop is weakly competitive lentil than if the following crop is strongly competitive barley. Weed control measures should attempt to maximize

the advantages presented by each cropping situation. An example would be the use of Poast for suppression of quackgrass in pea, as this chemical cannot be used in cereal crops.

Sound Agronomy for Weed Management

In weed management, the best defence is a strong offence.

• A vigourous and healthy crop has the best advantage in competition with weeds.

Stressed, unthrifty, and sparse crops leave gaps in a field where weeds flourish. Even within a farm, field selection can be important. Low-lying areas may be frost pockets, or frequently waterlogged. Eroded knolls have little waterholding capacity. Problem areas can be reduced by carefully matching the field and the crop.

Pulse plants are sensitive to residual herbicides. Therefore, it is important to select a field that does not have chemical or biological residues that can harm the crop. If a field has a history, which suggests residual herbicides [such as Ally, Amber, Assert, Attain, Banvel (spring or fall application), Curtail, Lontrel, Muster, Poast FlaxMax, Prevail, Rustler (pre-seed application), Tordon 202C, or Unity], or if high rates or spring applications of 2,4-D, MCPA, Banvel, or trifluralins have been used, then caution is advised. The herbicide label information and the marketing companies provide information on cropping restrictions. Keep a complete record of herbicides used in each field, for each year, and refer to recropping restrictions on the label.

The dissipation of herbicides depends not only on the weather, but also often on soil organic matter, texture, and pH. In some cases, a test plot may be needed. A small plot of the selected pulse crop should be planted in the field a year in advance to determine possible problems from herbicide residues. The test area should be allowed to mature to properly indicate potential problems as the crop may initially show normal growth, but may not set seed or may die later in the season. Chemical assays of the soil are also available from laboratories. To prevent problems, avoid overlap and doubling of herbicide applications on headlands and around obstructions. Field histories should be obtained when purchasing or renting farm land.

The Saskatchewan Agriculture and Food publication "Guide to Crop Protection" contains up-to-date information on the problems caused by active residues from herbicides. Growers should consult this publication and herbicide product labels to help them avoid residue problems.

The location of the pulse field relative to other fields may also be important. Pulses can be injured by herbicide drift of most broadleaf weed control herbicides. Pulses can also be infected by diseases from wind-borne pulse residues. Where practical, do not locate pulse crops directly downwind from a stubble field of the same pulse crop.

Within a crop type, variety selection can be important. Studies in Manitoba have shown that shorter stature pea plants are less competitive with weeds than those of taller stature. Semi-leafless pea varieties are nearly as competitive as normal-leafed varieties. However, at Melfort pea varieties did not have a different competitive ability against a mixed infestation of grassy and broadleaf weeds. The research indicates that the competitive ability of a pea crop depends strongly on the weed types and the environmental conditions. The Melfort study showed that the

pea crop was more competitive at higher seeding rates of up to 9 plants/ft^2 (100 plants/m^2). At lower seeding rates with reduced competition, the use of herbicides to control weeds becomes more important.

The timing of seeding can also effect weed competition. Weeds that emerge with or before the crop have much more effect on the crop than those emerging later. For instance, in Alberta, hairy nightshade plants that emerged with the crop caused an 80% loss in bean yield, whereas those that emerged 3 weeks after the crop caused only a 35% loss in yield. Early seeding may allow the crop to "get a jump" on the weeds. This may be especially true for weeds, such as green foxtail, that require warm soil for germination, and in no-till systems, where the lack of general soil surface disturbance inhibits early weed germination. Delayed seeding can be useful, if combined with pre-seeding or pre-emergent tillage to eliminate early and more competitive weeds before the crop emerges, and to activate soil-incorporated herbicides. Pre-emergent herbicides create the same advantage by clearing the field as the small crop seedlings emerge.

If sufficient moisture is present, shallow seeding provides for quicker emergence of the seedlings and allows the pulse crop to get ahead of the weeds. Large-seeded crops, such as most pulses, require good soil moisture for germination, and shallow seeding reduces the availability of moisture.

• The best depth for seeding is generally the shallowest that will provide adequate moisture for rapid germination and emergence.

• Seeding depth must also be considered in relation to the herbicides that are used. Shallow seeding reduces the risk of crop damage from the pre-plant soil incorporated trifluralins (Treflan, Rival, Advance, Bonanza, and Edge), but shallow seeding increases the risk of crop damage from Sencor (metribuzin) if heavy rains occur soon after application.

Higher seeding rates (up to nearly double recommended rates) can improve the competitive ability of lentil, pea, and dry bean. This may also be true for chickpea as well. Recommendations of the best seeding rates are based on weed-free, small-plot test results. The best seeding rate under weedier conditions may be higher. Seeding rate must be a compromise. Higher rates are more costly, and can increase the probability and spread of disease. Reduced seeding rates may help reduce disease and reduce seeding costs, but only when weed control is effective.

Seed quality is especially important for pulse crops. Rough handling, prolonged storage, disease, early frost, and improper desiccation can reduce germination of the seed and vigour of the seedling. Germination and vigour tests can identify possible problems.

Tillage

Many growers are adopting reduced tillage systems in order to conserve fuel, reduce erosion, and preserve soil quality. Some growers and researchers have been using direct seeding (seeding with minimum soil disturbance and maximum retention of crop residues) as part of their weed management strategy. In addition to increasing exposure to soil erosion, tillage stimulates weed seed germination by preparing the weed seedbed, warms the soil to speed up weed emergence, hides weed seeds from their predators, and puts weed

seeds in contact with soil moisture. In the absence of tillage, weed seeds are not as easily "deposited" in the "weed seed bank" in the soil. This is particularly true of weeds with dormancy such as wild oat. When the old "seed bank" is exhausted, some people are finding that their annual weed problems are dramatically reduced. However, perennial weeds can increase dramatically, and they can be much more expensive and difficult to control.

Some tillage techniques can be used effectively to manage weeds. The benefit of tillage must be considered in relationship to its cost and risks. For instance, fall tillage has traditionally been necessary for effective use of trifluralin for weed management, and also to control winter annual and biennial weeds. Fall tillage does expose the soil to the risk of wind and water erosion in the winter and spring, and reduces stubble that might trap snow and increase soil moisture. The relative costs and benefits depend on the nature of the land, the weather, the amount of surface residue, and the weed problems being addressed.

Fall or spring pre-seeding tillage can be used to control winter annual and biennial weeds, and is required to aerate and warm the soil to activate some soil incorporated herbicides. Spring tillage should control early emerging, summer annual weeds. Shallow tillage avoids bringing more weed seeds up to near the soil surface where they are more likely to germinate. Excessive tillage dries the seedbed, making shallow seeding less effective.

Post-emergent harrowing with a tine harrow can be used as a weed control technique in some pulse crops, but it is not a preferred weed control measure. Results are highly variable and depend heavily on weather conditions and both weed and crop stage. Only very small weed seedlings that have emerged from a shallow depth can be killed and this is usually not effective unless the operation is carried out on a hot day, when plants are slightly wilted, and the surface soil is dry. Harrowing should be avoided immediately after crop emergence to prevent damage. Stand damage may result in variable maturity of the crop. The recommended stages of the crop for harrowing are at the seedling stage (no more than 4 above ground nodes) for lentil and pea.

• If post-emergent harrowing is used, it should be done on a dry, warm, sunny day for the most effective weed kill and to reduce seedling damage and the spread of disease.

Some crop stand thinning is inevitable. An increase of about 15% in the seeding rate may compensate for harrowing losses. Harrowing should only be considered when the seed has been placed below the depth of the harrows to avoid disturbing the seed and the primary root system. Harrowing damp or wet plants increases plant damage and will also increase the spread of diseases such as ascochyta. Precautions to reduce the risk of crop injury include the use of tine or flexible harrows only and reduced ground speed. Cross harrowing and a reduced angle of harrow tines will also be helpful. Fields with heavy surface residue should not be harrowed, if bunching of the residue occurs.

Herbicide Use

Only a limited number of herbicides are registered for use in Saskatchewan pulse crops. As new crops are developed, herbicide registration often lags behind. A grower cannot simply assume that a prod-

uct, which is safe for one pulse, is safe for another.

Herbicide options are not available to control all weeds in all pulse crops. Some weeds must be controlled in other crops in the rotation. Even in crops such as pea, where a greater range of herbicide choices exist, herbicide use should not be considered as a cure-all. Herbicides can be used to salvage a crop and to reduce annual weed seed set, but a long term approach is required employing weed management options to their fullest potential in all crop years. Total weed control is not likely to occur and may not be economical or practical or needed. A more realistic goal is to reduce weed density to permit commercial cropping and to continually monitor practices to ensure new weed problems do not emerge.

Detailed information on the use of specific herbicides and the recommended rates are contained in the "Crop Protection Guide" updated annually by Saskatchewan Agriculture and Food.

Table 5.6 (in Chapter Appendix) summarizes the herbicides that are currently registered for use in pulses. Comments on each product are given here, but the user should always read and follow label instructions.

Assure is a grassy weed herbicide registered for use in pea and lentil. Less than acceptable weed control can occur if the weeds are under environmental stress due to drought, flooding or cool temperature conditions. If lentil or pea plants are stressed by drought or flooding, some crop injury can occur.

The liquid formulation of Avadex BW is a spring soil-applied herbicide that kills young wild oat seedlings as they germinate and emerge. Wild oat kill is usually rapid. Pea seedlings have good tolerance to the chemical. Application of Avadex BW is recommended before seeding the pea crop. Two shallow incorporations at right angles with harrows are recommended. Avadex BW is not recommended for soils with residue cover greater than 30%, or where harrowing is likely to increase the risk of soil erosion. Avadex BW requires moisture for activation. On hot, windy days, large losses of Avadex BW can result from delayed incorporation. Early germinating wild oat plants present prior to application will not be controlled so they must be removed by tillage.

Basagran is registered in dry bean and field pea for control of many annual and perennial weeds.

• Basagran is a contact herbicide which requires good leaf contact for best results.

Environmental stresses, like drought, flooding, hail, or changing temperature, reduce control and may cause some yellowing of crop leaves. Best results occur when daytime temperatures are between 20 and 28˚C . Basagran can be used when pea plants have 3 leaves, or when dry bean plants have from 1 to 3 trifoliolate leaves. The adjuvant Assist Oil Concentrate is recommended for improved control, particularly at an advanced growth stage. Basagran should not be tank mixed with other chemicals. Best results are obtained by using increased water volumes and applying it during active weed growth.

Edge (ethalfluralin) and the trifluralin formulations (Advance, Bonanza 400, QR5, Rival, Treflan) kill seedlings as they germinate. Lentil is very susceptible to crop injury if conditions are cold and dry.

• Edge is registered for use on lentil for fall applications only, with at least one incorporation completed at this time. Do not seed lentil more than 1.5 inches (4 cm) deep.

Edge and trifluralin formulations are not recommended for fields prone to erosion because they require intensive incorporation. Fall incorporation is especially damaging to erosion-prone soils. Although not registered for this use, studies at Scott and Indian Head, using surface-applied Edge and trifuralin under no-till conditions, have shown weed control and crop safety comparable with incorporated Edge and trifuralin. The recommended practice includes 2 incorporations, performed at right angles to each other. The first incorporation is done within 24 hours of application to prevent herbicide loss; the second incorporation is carried out at least 5 days after the first to ensure thorough mixing in the soil. For fall-applied chemicals, the second incorporation can be done in the fall, or for crops other than lentils, in the spring. Shallow tillage is recommended before seeding to activate the herbicide and warm the seedbed.

Deep seeding or environmental factors which delay seedling emergence increase the risk of crop injury, and may result in stand thinning and/or delayed maturity and reduced yield, particularly for lentil.

• Weed resistance to herbicides (Advance, Bonanza, Edge, Fortress, Heritage, Rival, Treflan) has been identified for green foxtail in Saskatchewan. As a precaution, do not use herbicides in Group 3 year after year.

Eptam 8-E is a pre-plant incorporated herbicide for use in dry bean production. It is highly volatile, and, therefore, requires incorporation immediately after application (preferably during the spray operation). A second incorporation, at right angles to the initial, is required. If environmental stress (cold, wet soil, extreme heat, drought) occurs at the time of application, a seeding delay of 10 days is required to minimize potential crop injury.

Fusion is a systemic, translocated herbicide, which rapidly causes yellowing of the leaves, and death of grassy weeds in 2 to 3 weeks. Best performance occurs if crop plants are not under stress. Treated plants should not be grazed. Early application to pulses is required as pea seed should not be harvested within 75 days of treatment and lentil seed should not be harvested within 82 days of treatment. Fusion should not be used in areas where it may drift into wildlife habitat or wetlands.

Hoe-Grass 284 is registered for use in pea, lentil and dry bean (white, black and pinto). Weed control is best if the weeds have not tillered, are small, and actively growing. Control will be reduced if the weeds are under stress from high temperatures or drought. Yellowing of treated plants occurs in 2 - 3 days, and this chlorosis progresses rapidly with death of the weeds in about 14 days. Lentil is tolerant to Hoe-Grass 284 at all stages of growth, but in hot, humid weather, leaf cupping and a transient leaf burn may occur. Other pesticides should not be applied within 4 days of application of Hoe-Grass, and treated fields should not be grazed prior to harvest.

Lexone DF and Sencor are systemic post emergent herbicides that kill susceptible plants by inhibiting photosynthesis. Control symptoms may not be noticeable for 3 to 7 days after treatment. Continuous agitation is required to keep the metribuzin in solution. Although these herbicides act primarily through the foliage, rain may move them down to the root system where they may cause injury to lentil, pea and chickpea (lentil and chickpea are more sensitive than pea) plants that are sown on course textured soil less than 2 inches (5 cm) deep or on soil that has less

than 4% organic matter. Damage is also more likely, when the crop is stressed by high, or low temperatures, or frost, or the crop is not in the early growth stage, or when less than 70 L/ac of water is applied with the herbicide.

• Applications on chickpea should be applied up to 2.5 inches (6 cm) of plant height, when plants have 1 – 3 above ground nodes. Very severe crop injury can occur with applications beyond this growth stage since the leaves are burned off.

• A full rate of metribuzin applied to lentil plants at the 6-node stage on a hot day will burn the leaves off.

• Under some field and weather conditions, weed control is improved with a split application (pea and lentil) with the first application (2/3 rate) at the cotyledon to 2-leaf stage of the mustard-type weeds and the second application (1/2 rate), if a second flush of weeds emerges 7 to 10 days later.

Split application usually reduces damage to the lentil crop. Split applications are not to be used on processing pea. Wild oat herbicides should not be applied within 3 days of application of metribuzin. Treated crops should not be fed to livestock within 70 days of application for Lexone DF and 30 days for Sencor.

MCPA is a translocated phenoxy herbicide that causes rapid undifferentiated growth, and death in susceptible plants. It may delay maturity in pea, and the pea crop under stress may be slow to recover. The recommended stage for treatment is before the 6th node stage of pea. Only the amine or sodium salt formulations are recommended in peas. MCPA is not recommended for other pulse crops.

Odyssey is a systemic herbicide registered for use in field pea. Grassy weeds begin to yellow and broadleaf weeds turn yellow, red or purple in colour within 3 to 10 days. Death of treated weeds occurs in 7 to 21 days. Since the product is a systemic herbicide, efficacy may be reduced if stress conditions inhibit active weed growth.

Pea Pack is a premix of Sencor 75DF and MCPA sodium salt for use in field pea only. Both are systemic in nature and control of susceptible weeds occurs within 7 to 10 days. It should not be used if pea seed is planted less than 2 inches (5 cm) deep or on soils with less than 4% organic matter. Apply before pea vines are 6 inches (15 cm) tall; do not harvest pea seed within 70 days of application. Extremes in temperature after application may cause some crop injury, and rainfall within 6 hours of application may reduce control.

Poast Ultra (sethoxydim) is a very effective translocated grass herbicide that can be safely applied at all stages of pulse crop growth. Control is best when the annual grassy weeds are small and actively growing. Annual grassy weeds stop growing within hours after treatment and the vegetation slowly turns brown. Death of the grassy weeds takes 7 to 21 days, depending on growing conditions and stage of application. Top-growth control of quackgrass can be expected for 6 to 8 weeks, but in a weakly competitive crop, like lentil, some re-growth generally occurs prior to harvest. Drought, flooding, and prolonged periods of heat or cold can reduce grass control. Poast Ultra may be tank-mixed with Pursuit for field pea production. Other pesticides should not be used within 4 days of Poast application, and 5 days between the application of Sencor. Poast requires the addition of Merge surfactant. Poast must not be applied to lentil within 65 days of harvest. Avoid drift of Poast onto cereal crops.

Pursuit is a herbicide with residual soil activity. It is absorbed by roots and leaves of plants, stops growth, and leads to the death of susceptible plants. A surfactant, such as AgSurf or Agral 90, must be added to the spray solution. It is not recommended for pea and dry bean (pinto, pink and red varieties only) in the Brown or Dark Brown soils because of the risk of prolonged soil activity in drier areas. Even in the recommended areas, recropping potential is reduced by the use of this chemical as only barley, wheat (not durum), lentil, Smart canola or alfalfa can be grown. Over-application may result in crop injury, and may limit the recropping possibilities even further. A field test plot should be grown the year before growing any other crop. Pea can be treated with Pursuit up to the 6-leaf stage, and bean to the second trifoliolate leaf stage. Treatment or drift into wildlife habitats should be avoided. A pre-harvest interval of 60 days for pea, and 75 days for bean, is recommended. Crops should not be grazed or cut for hay. Do not apply Pursuit to the same field two years in a row.

Glyphosate herbicides can be effective as pre-emergent control of winter and early emerging spring annual weeds in all pulse crops, and in pre-harvest applications to remove green weeds in pea, lentil and dry bean. However, pre-harvest application results in abnormal seedlings and the seed should not be used for planting.

Select is a systemic grassy weed herbicide that provides control within 1 to 3 weeks. Affected plants discolour to yellow, purple and finally brown. Pea, lentil and dry bean are tolerant to Select at all growth stages but application on chickpea is required prior to the 9-node stage. Optimum control is obtained if application occurs prior to weeds tillering.

If trifluralin (Advance, Bonanza, Rival, Treflan) is used, fall incorporation provides the advantages of uniform distribution of active ingredient and conservation of spring soil moisture by reducing the need for spring tillage. Fall incorporation may result in increased crop tolerance, and the reduction in spring tillage should allow earlier seeding. Two incorporations are required, the second at right angles to the first. Only fall applications of trifluralin products are recommended for lentil as spring application can result in crop injury, delayed seeding, and because of incorporation tillage, a dried-out seedbed. Fall-incorporated products are not recommended, if the soil is prone to erosion from wind or water in the fall or spring or if fall soil conditions prevent thorough incorporation. A spring tillage operation is still recommended to warm and aerate the soil to activate those herbicides which are fall applied. Deep seeding or environmental factors which delay seedling emergence increase the risk of crop injury from these products and may result in stand thinning, delayed maturity, and reduced yield. Although not registered for this use, studies at Scott and Indian Head using surface applied trifluralin under no-till conditions have shown weed control and crop safety comparable with incorporated trifluralin. This method of application would provide important advantages for control of erosion.

Tropotox Plus, a systemic herbicide, is registered for use in pea. Symptoms of activity include the development of deformed leaves, curved stems and reduced plant height 2 to 7 days after application. Weed death occurs within 3 to 4 weeks. No tank mixes are registered.

Venture 25 DG is a systemic grassy weed herbicide for use in

pea and lentil. Results are best when applied prior to tillering in target weeds. Weed death occurs within 3 to 4 weeks after application. The herbicide must be mixed with an adjuvant, Turbocharge. In pea production Venture can be tank mixed with Pursuit.

• Weed resistance to Group 1 herbicides (Assure/Assure II, Hoe-Grass 284, Poast Ultra, Select and Venture) has been identified for wild oat and green foxtail in Saskatchewan. As a precaution, do not use herbicides in Group 1 year after year.

Other Herbicide Practices

Some winter annual weeds in the mustard family (flixweed and shepherd's purse) are not controlled by herbicides registered for lentil. Pre-seeding glyphosate application or pre-seeding tillage can be effective. Some growers have experimented with late fall or very early spring applications of 2,4-D or MCPA to control these weeds prior to seeding lentil. These treatments are very effective as a control measure and have the added benefit of low cost.

• However, they are not recommended for lentil because of the high risk of crop injury from carry over on the soil or near the surface, particularly under dry, cool conditions.

Direct seeding or use of discers often results in the seeds being directly covered with high residue content soil. Tillage to incorporate pre-plant herbicides effectively dilutes these residues.

Quackgrass, perennial sowthistle, and Canada thistle are difficult weeds to manage in a pulse crop and are easier to control in other years of the rotation. Pre-harvest application of glyphosate (Roundup, Renegade, Victor, Glyfos) in the previous crop is one method that can be used to control these weeds. Spot spraying may be advisable, as pulse losses are generally severe. Wild buckwheat, cleavers, Russian thistle, and kochia are weeds that can remain green and make harvesting difficult, and interfere with drying and storage of the crop. Weed management is easier, if fields with infestations of these weeds are avoided, or if these weeds are controlled in other years in the rotation.

Glyphosate herbicides can be used as pre-harvest weed control in pea, lentil and dry bean, one or two weeks prior to harvest. Earlier application can result in reduced crop yield, reduced quality, and residue in the seed.

• As germination of the seed and vigour of the seedling can be reduced, pre-harvest Roundup is not recommended for crops grown for planting seed production.

Glyphosate is not a recommended crop desiccant. In addition, glyphosate can also be used as a pre-seeding or pre-emergent burnoff treatment and it leaves no harmful residue.

Know When to Treat

All weed control methods have economic and environmental costs. Several factors are involved in determining whether these costs are justified.

Weeds should not be automatically considered a problem that requires drastic action. The competitive effect of weeds is determined by the type of weeds, the number of them, the time that they emerge relative to the crop, and the weather. In low stature and slow emerging pulses, the competitive effect of weeds is generally much greater

than it is in other crops. Weeds are only worth controlling if the damage caused by the weed (yield loss, harvest difficulty, quality loss, weed seed set) outweighs the cost of control.

• Generally, it is advisable to spend more herbicide dollars on the less competitive and more valuable pulse crops than on the more competitive cereal crops.

The weed "problem" should be considered in the context of the entire farm operation. The grower has to decide, if the weed problem in a field is cosmetic or economic prior to determining the control method. For instance, consider wild oat in pea grown as green feed for livestock. Would the value of the wild oat as livestock feed offset the reduction in pea yield from competition, or would the loss in value be greater than the cost of a wild oat herbicide? Some weeds, such as a volunteer crop, can be economically separated and sold. **A grower must be aware that weed competition can cause a disastrous reduction in pulse crop yield. Effective weed control is the key to profitable pulse production.**

Control measures have different levels of effect on different weeds. When a herbicide control exists for only some of the types of weeds in a field, the surviving weeds may still be able to out compete the crop. For example, treating a field with Sencor to control wild mustard and stinkweed may be of no benefit if the field also has a heavy stand of wild buckwheat, which has not been controlled. Some fields may be unsuitable for pulse crops if they contain dense stands of weeds for which no control exists.

In the final analysis, all weed management is a compromise. The best solutions are field-specific and depend on land use, rotations, available equipment, and the cost.

It is important to take advantage of different crops grown in the rotation to attack the weed problems in a field. This will include the use of summerfallow tillage, chemfallow, spot treatments, alternate and inexpensive cereal crop chemicals, field mapping, soil bioassays, herbicide use records, and a clear plan to ensure that weeds not controlled in pulse crops are attacked in other portions of the rotation.

Biological Control

Biological weed control is the use of living organisms to control weeds, such as the use of livestock to graze weeds. Insects have been imported from European and Asian countries and released on rangeland weeds that were difficult to access for chemical control. Today, bio-control is moving to encompass a broader perspective. This may include the encouragement of helpful local insects, the herbicide-style application of certain weed diseases, and all other forms of biological control.

Wild tomato can be very effectively controlled by use of Colorado potato beetles, but the beetles are not commercially available.

Biological agents may be more available in the future.