Pest Management Strategic Plan for Pulse Crops (Chickpeas, Lentils, and Dry Peas) in the United States and Canada

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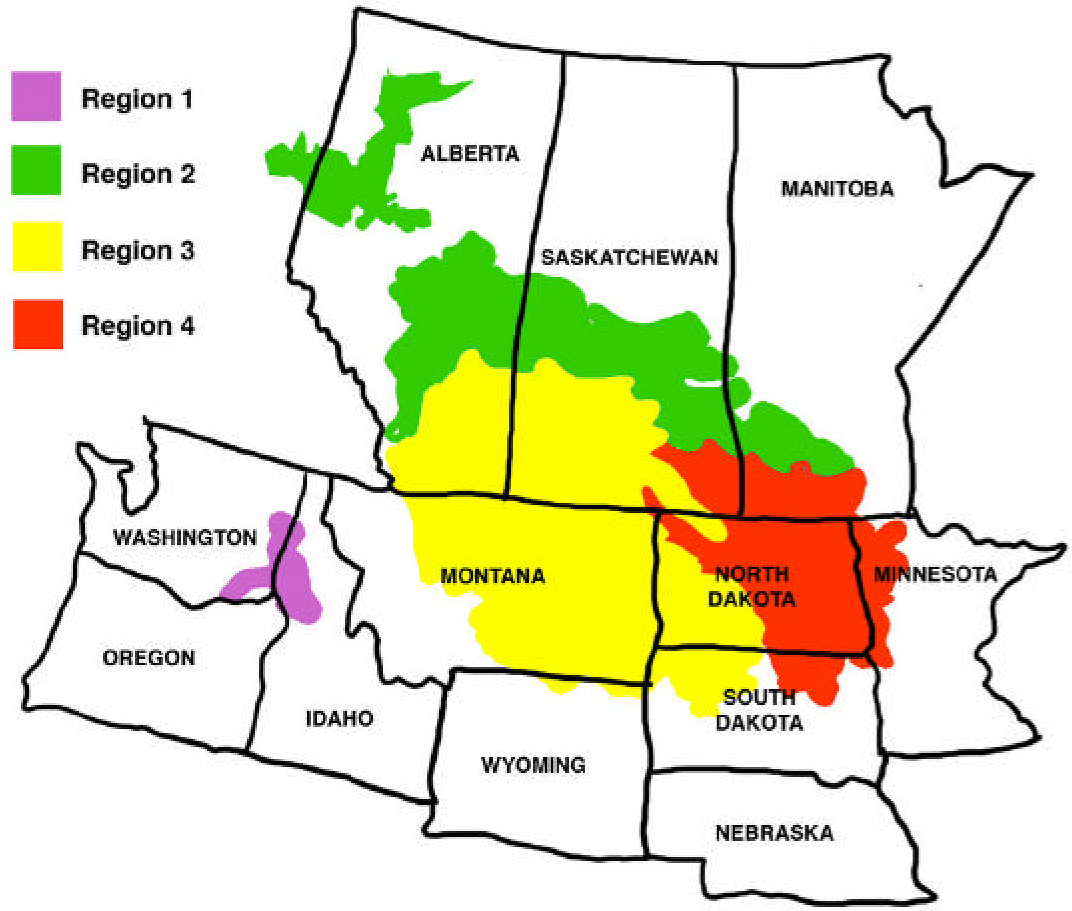
Region Map

Throughout this document, four pulse growing regions are discussed as delineated in the map below. Region 1 is located in the states of Washington, Oregon, and Idaho. Characterized by its warm, semiarid climate, much of this area is also referred to as "The Palouse." Region 2 is located entirely in Canada. Known also as the Canadian Parkland region, it includes cooler, subhumid parts of the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba. Region 3 is warmer and semiarid. It includes the Northern Plains states of Montana and the Dakotas, as well as southern parts of Alberta and Saskatchewan. Region 4 includes moister areas of the Northern Plains states, including Montana, the Dakotas, and Minnesota along with some southern portions of Saskatchewan and Manitoba provinces.



NOTE: Trade names for various products are used throughout this document as an aid for the reader in identifying these products. The use of trade names does not imply endorsement by the work group or any of the organizations represented.

Background

Edible seeds of legumes are known as pulses. They include peas, beans, lentils, and chickpeas. The term “pulse” comes from the Latin word “puls,” which means a thick soup. For the purposes of this document, the term “pulse crops” will represent chickpeas, lentils, and dry peas. No other pulse crops will be included in the discussions.

All three of these pulse crop species are a part of the larger plant family known as the Fabaceae or legume family. The Fabaceae family includes about 600 genera and 13,000 species, making it the third largest family within the plant kingdom. Further taxonomic classification puts the pulse crop species in the Faboideae subfamily and the Fabeae tribe. This family includes cultivated species such as alfalfa, soybeans, and many edible beans.

Pulses are considered environmentally friendly because of their reduced dependence on fossil fuels. Instead of requiring fertilizer applications, they are able to obtain much of their nitrogen requirement from the atmosphere by forming a symbiotic relationship with Rhizobium bacteria in the soil. Pulse crops’ low crop residues and low carbon-to-nitrogen ratios eliminate the need for burning and make rotating to the next crop using reduced tillage very easy.

Pulse crops have a hypogeal type of germination meaning that the seed leaves (cotyledons) remain below ground. Soybeans and dry beans have an epigeal type of germination, which means the seed leaves emerge from the soil. The hypogeal germination makes pulse crops more frost-tolerant than soybeans or dry beans. Additionally, pulse crops are more tolerant of post-plant, pre-emergence, or early post-emergence tillage operations such as harrowing, culti-packing, or rotary hoeing (each of which disturbs the soil) than are soybeans or dry beans. Later (mid-season to late-season) mechanical operations are less practical because of the crops’ prostrate growth habit and low pod set.

For further information on production and other aspects of these crops, refer to the U.S. Department of Agriculture Crop Profiles website, available on the Internet at URL http://pestdata.ncsu.edu/cropprofiles/ .

Chickpeas (*Cicer arietinum*)

Chickpeas are an annual grain legume and are believed to be one of the first legumes cultivated by humans. Among pulse crops marketed as human food, world chickpea consumption is second only to dry beans. They are classified as two types, “desi” or “kabuli,” based on seed size, color, and the thickness and shape of the seed coat. About 90 percent of chickpeas, the majority of which are desi types, are consumed in India.

Desi types are usually smaller, angular seeds with thick seed coats that range in color from light tan and speckled to solid black. Desi chickpeas require a specialized seed-coat-removal process if used for human food. The process, called decortication, requires adjusting the moisture level of the seeds to facilitate the mechanical removal of the thick seed coat. The seeds, which after decortication resemble a small yellow pea, are processed into numerous South Asian ethnic food products.

Kabuli types, also known as “garbanzo beans” in the United States, are larger seeds with paper-thin seed coats that range in color from white to pale cream-color to tan. In North America, most kabuli chickpeas are marketed as canned chickpeas for salads. Kabuli chickpeas are also marketed as dry chickpeas and ground flour for baking purposes.

In the United States, chickpea production is located in Idaho, Washington, Oregon, Montana, North Dakota, South Dakota, Nebraska, Colorado, and California. Production has expanded to over one million acres in the Canadian Prairies (primarily Saskatchewan).

Chickpeas are a good livestock feed. Feed values and feeding studies for kabuli and desi chickpeas have been compared to peas, barley, grain, and soybeans. Chickpeas have higher oil content than other pulse crops and provide slightly more protein and slightly less energy than peas.

Chickpea plants are erect with primary, secondary and tertiary branching, resembling a small bush. They flower profusely and have an indeterminate growth habit, continuing to flower and set pods as long as conditions are favorable. Pod set occurs on the primary and secondary branches and on the main stem. The individual round pods generally contain one seed in kabuli types and often two seeds in desi types. Chickpeas have deeper taproots than peas and lentils. This has an impact in moisture-deficient areas.

Lentils (*Lens culinaris*)

In the United States, lentils are grown primarily in the Palouse (Region 1) and upper Midwest (Regions 3 and 4). There are five to six market classes of lentils grown in these regions, based on seed size, cotyledon color, and seed coat coloration.

In Canada, lentils are grown primarily in Saskatchewan. This province is the world’s largest exporter of lentils, with 1.7 million acres in production. Smaller acreages are grown in Alberta and in Manitoba. Canada also produces five to six market classes of lentils.

Lentil plants are herbaceous, with slender stems and branches. Plant height ranges from 12 to 15 inches for most varieties, but can vary from 8 to 30 inches depending on variety and environment. Plants have a slender taproot with fibrous lateral roots. Rooting patterns range from a many-branched, shallow root system to types that are less branched and more deeply rooted. The taproot and lateral roots in surface layers of the soil have nodules that vary in shape from round to elongate. Stems of lentil plants are square and ribbed and usually thin and weak. Branches arise directly from the main stem and may emerge from the cotyledonary node below ground or from nodes above ground. Leaves are relatively small compared to those of other large-seeded food legumes. Pods are oblong, laterally compressed, 6-20 mm long and 3-10 mm wide, and usually contain one or two lens-shaped seeds. Seed diameter ranges from 2 to 9 mm and colors range from light green or greenish red to gray, tan, brown or black. Purple and black mottling and speckling of seeds are common in some varieties. Varieties grown in North America include large green types with seed diameters from 6 to 7 mm and with yellow cotyledons (Laird, Brewer, Richlea, Mason, Pennell, Merrit, and others), small red cotyledon types (Crimson, Robin), Spanish browns (Pardina), small yellow types (Eston), and large red types (Redchief). Other types may be grown to a lesser extent. The lentil crop in North America is planted in early spring and harvested in late summer.

Dry Peas (*Pisum sativum* and *P. sativum* ssp. *arvense*)

U.S. dry pea production is located in Washington, Idaho, Oregon, Montana, and North Dakota. Dry peas or "field peas" are a cool-season annual crop. They differ from succulent peas in that dry peas are marketed as dry, shelled products for either human food or livestock feed, whereas succulent peas are marketed as fresh or canned vegetables. There are two main types of dry peas. One type has normal leaves and vine length of 3 to 6 feet. The second type is semi-leafless (actually with modified leaflets) with shorter vine lengths of 2 to 4 feet.

In Canada, dry peas are grown in all three prairie provinces (Alberta, Manitoba, and Saskatchewan) on 3.5 million acres. Dry pea has been the leading alternative crop as farmers move to diversify crop production in the prairies. Mainly yellow and green peas along with other minor classes are grown, with approximately two-thirds of production in yellow types. Most varieties have a white flower, with recent years seeing an increase in the production of northern-European origin varieties with the semi-leafless type.

Dry peas emerge and perform well in a variety of seedbeds including direct seeding into grain residue. Dry peas are typically grown following cereal crops. As with the other pulse crops discussed here, most dry peas are spring-seeded; optimal planting dates range from mid-March to mid-May when soil temperatures are above 40 degrees F (4 degrees C). In most years, delayed planting lowers quality and seed yield. Dry peas are adapted to grow during the cool season when evapo-transpiration is minimal. In Region 1, they rely on stored soil moisture for a large part of their growth cycle. Fall-seeded peas (Austrian winter peas) are grown in some parts of the United States and there is potential for development of edible types of dry peas and lentils to be fall-sown in the United States as well.

Depending on variety, dry peas start flowering after a specific number of nodes are reached and flowering continues until drought or nitrogen deficiency brings it to an end. Dry pea varieties have either a determinate or indeterminate flowering habit. Determinate varieties mature in 80 to 90 days, indeterminate varieties in 90 to 100 days. Dry pea harvest begins in late July when pods are dry and seed moisture is 8% to 18%, depending upon the growing region. They are combined directly in the field. A timely harvest is important to avoid post-maturity disease, seed bleaching, and seed shatter.

EPA and FQPA

The U.S. Environmental Protection Agency (EPA) is now engaged in the process of re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA) of 1996. The Agency is examining dietary, ecological, residential, and occupational risks posed by certain pesticides. EPA's regulatory focus on the organophosphate (OP), carbamate, and B_2 carcinogen pesticides has created uncertainty as to these pesticides' future availability to growers. At some point, the EPA may propose to modify or cancel some or all uses of these chemicals on pulses. The regulatory studies that EPA requires place significant burdens of time and expense on registrants. In cases where these burdens outweigh the commercial viability of the product, companies may opt to voluntarily cancel certain registrations for pulse crops.

The U.S. Department of Agriculture (USDA), the EPA, the land-grant universities, and the pulse industry need to proactively identify research, regulatory, and educational needs in order to reduce the reliance on certain pesticides and identify effective alternatives.

PMRA

In Canada, pesticide registration is a responsibility of the Pest Management Regulatory Agency (PMRA) of Health Canada. Registration is carried out under the authority of the Pest Control Products Act (PCPA) and involves conducting science-based health, environmental, and value (including efficacy) assessments of each pesticide before deciding if it should be approved for use in Canada.

PMRA is also involved in the re-evaluation of older pesticides, using current scientific approaches to examine the continued acceptability of older active ingredients and their end-use products. This re-evaluation program may have implications for pulse crops. Recently, however, a new initiative to help increase the availability of reduced-risk pesticides, including minor use products, was announced by the Ministers of Health and Agriculture and Agri-Food. This initiative will assist in the registration of pesticide products that are used in such small quantities that manufacturers find the sales potential is not sufficient to seek a registration in Canada.

Harmonization

In the United States and Canada, EPA and PMRA are working together to develop common or compatible international approaches to pesticide review, registration, and standard-setting for pesticides, while maintaining current high levels of protection of public health and the environment and supporting the principles of sustainable pest management. EPA and PMRA believe that making pesticide regulatory programs more consistent internationally will lead to: (1) improved food safety; (2) reduced regulatory burden on national governments; (3) strengthened scientific procedures; (4) fewer trade problems; and (5) better access to lower-risk pesticides and integrated pest management (IPM) programs that help reduce reliance on conventional pesticides.

To North American farmers, harmonized regulatory systems mean greater efficiencies on the farm through faster access to IPM crop protection tools.

The Work Group and the PMSP

A work group consisting of U.S. and Canadian growers, commodity groups, pest control advisors, regulators, and university specialists along with representatives from USDA, EPA, AAFC, and PMRA met for two days in Saskatoon, Canada in June of 2002. The purpose of the meeting was to identify the needs of pulse growers in the two countries with reference to possible regulatory actions regarding pesticides. The outcome of this exercise resulted in a list of critical needs, general conclusions, and tables listing the timing of operations and the efficacies of various management tools for specific pests. These materials have been compiled and reviewed by task force members and are presented in this Pest Management Strategic Plan (PMSP). This document and its appendices are intended to serve as a comprehensive foundation for pest management transition in pulse crops in the United States and Canada.

The following list summarizes those needs determined by the task force to be the most critical to U.S. and Canadian pulse crop pest management. Overall top priorities are listed first, followed by the top priorities for each of the three pulse crops under examination. The remainder of the document is organized by crop production period from pre-plant through post-harvest. Each crop production period is subdivided by pest (e.g., weed, disease, insect) with critical needs in the areas of research, regulation, and education identified at the end of each section.

U.S. OVERALL TOP PRIORITIES

Research

- Ascochyta management and control
- Biology / ecology of winter pulses
- Expansion of post-emergent herbicide labels
- Fungicides for foliar disease control
- Insecticide research, particularly dimethoate alternatives

Regulatory

- Retain dimethoate registration
- Harmonization of products, cropping zones, maximum residue levels (MRLs), etc.
- Full label for sulfentrazone (Spartan), 2,4-DB, thiabendazole (LSP, Mertect), and pyridate (Tough); note that pyraclostrobin (Headline) and azoxystrobin (Quadris) were originally on this list but their registrants announced the products’ registrations in March and April 2003, respectively
- Get pulse crops on EPA's PR 97-2 list for all relevant crop/pest combinations

Education

- Put herbicide mode of action on label
- Tell EPA and registrants what pulse industry needs

- Educate growers on available resources
- Transfer predictive models for ascochyta blight to growers
- Update PMSP in 2 years

U.S. CROP-SPECIFIC PRIORITIES

Chickpeas

Research

- Develop post-emergent broadleaf herbicides
- Develop larger kabuli-type chickpea varieties
- Develop earlier-maturing varieties
- Develop cost-effective fungicides
- Investigate biology and epidemiology of ascochyta blight for modeling risk management
- Increase breeding efforts (blight resistance particularly)
- Develop alternative to glyphosate (Roundup Ultra)

Regulatory

- Work with regulators to decrease delay in Section 18 fungicide approvals, particularly those involved with disease resistance management
- Expedite full registration of fungicides
- Register additional active ingredients on chickpea in general (use crop grouping approach)
- Get pulse crops on EPA's PR 97-2 list for all relevant crop/pest combinations
- Expedite full label registration of sulfentrazone (Spartan) and pyridate (Tough); note that pyraclostrobin (Headline) and azoxystrobin (Quadris) were originally on this list but their registrants announced the products' registrations in March and April 2003, respectively

Education

- Attract priority attention from fungicide registrants
- Industry education about registration techniques and funding sources for research
- Conduct disease identification courses
- Transfer predictive models to growers

Lentils

Research

- Increase breeding efforts (e.g., disease resistance, shatter resistance, etc.)
- Investigate biology and ecology of winter lentils (crop-pest interaction)
- Develop pre- and post-emergence broadleaf herbicides

- Develop an alternative to dimethoate
- Investigate environmentally friendly/efficacious weed control in post-harvest situations (i.e., winter wheat or fallow)
- Develop seed treatment for aphid control
- Develop a forecasting model for pea aphid/lygus bug (virus transmission problems)
- Develop additional herbicides in wheat that will not harm lentils grown in a later rotation

Regulatory

- Obtain 2,4-DB registration
- Retain dimethoate registration
- Need more chemistries (all types) for lentils
- Decrease 3-year requirement between pulse rotations for crop insurance coverage (ND, MT)
- Expedite bifenthrin (Capture 2E) and lambda cyhalothrin (Warrior) registrations
- Harmonization of chemical registrations
- Expedite full registration of thiabendazole (LSP, Mertect)

Education

- Inform EPA about the critical use of dimethoate
- Provide additional information on weed control to growers, especially to new growing areas
- Get registrants to add lentils to labels when data is available for crop groups
- Get information to crop insurance people
- Inform growers about aphid models
- Develop better communication with registrants

Dry Peas

Research

- Develop cost-effective control methods for weevils in field
- Develop seed treatment for aphid and disease control
- Develop pea weevil materials that will not cause flaring of aphid populations
- Increase breeding efforts for pest management
- Develop additional cost efficient fungicides
- Develop new pre- and post-emergent herbicides
- Develop a replacement for dimethoate
- Conduct biological and ecological studies of winter peas
- Investigate vertebrate control (voles)

Regulatory

- Harmonization of imazethapyr (Pursuit) registration and product pricing
- Expedite sulfentrazone (Spartan) registration
- Need more fungicides registered
- Expedite bifenthrin (Capture 2E) and lambda-cyhalothrin (Warrior) registrations
- Retain dimethoate registration
- Obtain different allowable residue levels when crop used as feed
- Extend seed treatment labels to include peas

Education

- Start tracking pesticide use data
- Educate growers about vertebrate control
- Inform EPA about dimethoate criticality
- Provide additional information on weed control to growers, especially to new growing areas
- Get registrants to add peas to labels when data available for crop groups
- Get information to crop insurance people
- Get growers information on aphid models
- Develop better communication with registrants
- Attract priority attention from fungicide registrants
- Educate industry about registration techniques and funding sources for research
- Conduct disease identification courses
- Transfer predictive models to grower

CANADA OVERALL TOP PRIORITIES

- Develop super-crop groupings (combinations of crops with similar pest management needs for joint regulatory consideration)
- Pesticide harmonization
- Additional IPM crop protection tools for disease management
- Additional IPM crop protection tools for broadleaf weed management
- Work with international trade partners so that MRLs don't become trade irritants
- Catch up pesticide registration and on-farm food safety; develop list of products that need to be registered. These will include the following immediate priorities: (1) ethalfluralin (Edge, Sonalan) on chickpeas, (2) deltamethrin (Decis) and permethrin (Ambush) on chickpeas, (3) bentazon (Basagran) applied pre-bloom on peas for sow thistle control, and (4) broadleaf weed control in pulse crops.
- Re-evaluate zone maps for residue trials
- Develop crop profiles
- Define, monitor, and document IPM practices in pulses
    - Educate regulators

- Educate public
- Standardize measurements

CANADA CROP-SPECIFIC PRIORITIES

Chickpeas

Research

- Enhance ascochyta-resistance breeding programs
- Improved control/management tools and practices for ascochyta
    - Modeling/forecasting/monitoring tool
    - Fungicide chemistry
    - Fungicide rotations
- Increase breeding for early maturity
- Develop broadleaf weed control tools
- Improve harvest management tools (desiccants, growth regulators, defoliants)
- Investigate wireworm management through seed treatments or insecticides
- Develop alternative reduced-risk fungicides products and/or methods

Regulatory

- Expand labels for ethalfluralin (Edge, Sonalan), diquat, imidazolinones
- Register sulfentrazone (Spartan), strobilurins, and pyridate (Tough)
- Harmonize (with U.S.) and streamline registration process
    - Compressing trial zones
    - Increase acceptance of U.S. data
    - Expedite setting up a Canadian IR-4
- Pulse industry to work with PRMA on regulatory flexibility to maintain pulse crops in the minor use system, to obtain product registration in pulse crops
- Industry to explore potential of picking up minor pesticides
- Improve coordination within Canada to generate data to fill requirements for minor use registrations
- Examine “novel trait” plant definition

Education

- Educate growers about disease management, resistance management, disease identification, and field scouting
- Improve stakeholder awareness of regulatory requirements for pulses
- Educate growers about rotations and other cultural pest management strategies
- Educate growers about pesticide persistence
- Develop crop profiles
- Harmonize (with U.S.) and streamline registration process

  - Compressing trial zones
  - Increase acceptance of U.S. data
  - Expedite setting up a Canadian IR-4
- Pulse industry to work with PRMA on regulatory flexibility to maintain pulse crops in the minor use system, to obtain product registration in pulse crops
- Industry to explore potential of picking up minor pesticides
- Improve coordination within Canada to generate data to fill requirements for minor use registrations

Lentils

Research

- Enhance ascochyta and anthracnose resistance breeding programs
- Continue research in control/management tools and practices for disease
  - Modeling/forecasting tool
  - Fungicide chemistry
  - Fungicide rotations
- Explore broadleaf weed control tools
- Evaluate potential of new strobilurins

Regulatory

- Label expansion for imazethapyr (Pursuit) and other imidazolinones
- Register strobilurins
- Harmonize (with U.S.) and streamline registration process
  - Compressing trial zones
  - Increase acceptance of U.S. data
  - Expedite setting up a Canadian IR-4
- Pulse industry to work with PMRA on regulatory flexibility to maintain pulse crops in the minor use system, to obtain product registration in pulse crops
- Industry to explore potential of picking up minor pesticides
- Improve coordination within Canada to generate data to fill requirements for minor use registrations
- Examine “novel trait” plant definition

Education

- Educate on disease management, resistance management, disease identification, and field scouting
- Stakeholder awareness of regulatory requirements for pulses
- Educate on rotations and other cultural pest management strategies
- Educate on pesticide persistence
- Develop crop profiles
- Harmonize (with U.S.) and streamline registration process
  - Compressing trial zones

    - Increase acceptance of U.S. data
    - Expedite setting up a Canadian IR-4
- Pulse industry to work with PRMA on regulatory flexibility to maintain pulse crops in the minor use system, to obtain product registration in pulse crops
- Industry to explore potential of picking up minor pesticides
- Improve coordination within Canada to generate data to fill requirements for minor use registrations

Dry Peas

Research

- Develop new annual broadleaf products to replace imidazolinones
- Investigate disease management tools: modeling, resistance, decision-making tools
- Develop harvest aid management tools
    - Shorter grower season areas
    - New market classes
- Continue breeding for mycospharella resistance
- Develop new stand-up leafy peas

Regulatory

- New labels: strobilurins, broadleaf herbicides
- Harmonize (with U.S.) and streamline registration process
    - Compressing trial zones
    - Increase acceptance of U.S. data
    - Expedite setting up a Canadian IR-4
- Pulse industry to work with PRMA on regulatory flexibility to maintain pulse crops in the minor use system, to obtain product registration in pulse crops
- Industry to explore potential of picking up registration duties for minor pesticides
- Improve coordination within Canada to generate data to fill requirements for minor use registrations
- Examine “novel trait” plant definition

Education

- Educate growers about harvest management
- Educate stakeholders about regulatory requirements for pulses
- Educate growers on rotations and other cultural pest management strategies
- Educate growers on pesticide persistence
- Develop crop profiles
- Educate general public on pest management and role of pesticides in pulse crop production
- Implement professional development requirement for regulators

Pest Management Strategic Plan Foundation

The remainder of this document is an analysis of pest pressures during the various growth stages of pulse crops. Key control measures and their alternatives (current and potential) are discussed. Differences between production regions throughout the United States and Canada are discussed where appropriate. All three pulse crops are discussed in each section, with differences and similarities in pest control noted. In order to orient the reader before discussion of specific crop stages, Activity Tables for cultural pest management and crop monitoring activities are provided in Appendix A.

Pre-Plant

It is important to consider field history in pulse production. The decision to grow pulses in a given field is typically made a year or two in advance to allow for proper site preparation. Therefore, the "pre-plant" period for any field includes all production seasons subsequent to the previous pulse crop and the late fall, winter, and early spring just prior to the planting of the pulse crop.

Many herbicides used in small grain production may persist in the soil, resulting in pulse crop injury and yield loss (see Table 1). Rotational intervals depend in part upon how long herbicides remain in the soil. Factors that affect herbicide persistence include soil pH, moisture, temperature, texture, and organic matter. In areas with a dry climate and short growing season, herbicides generally degrade slower than in warmer, moister areas. Sulfonylurea herbicides (Ally, Amber, Canvas, Finesse, Glean, and Peak) persist longer in higher pH soils. When soil pH exceeds 7.5 to 7.9, sulfonylurea residues may remain in the soil much longer than described on the label. Under such conditions, a field bioassay is required the year before seeding pulses.

TABLE 1. Minimum plant-back interval following herbicide application. (The table is meant to be a guide only and should not be considered a recommendation. Consult specific product label to determine plant-back interval of pulse crops and other crops.)

HERBICIDE	CHICKPEAS	LENTILS	DRY PEAS
2,4-D*	30 days to 3 months	30 days to 3 months	30 days to 3 months
Achieve (tralkoxydim)	106 days	106 days	106 days
Aim (carfentrazone-ethyl)	12 months	12 months	12 months
Ally** (metsulfuron methyl)	10-34 months	10-34 months	10-15 months
Amber*** (triasulfuron)	4 months	4 months	4 months
Assert (imazamethabenz)	15 months	Following year to 15 months	Following year to 15 months
Avenge (difenzoquat methyl sulfate)	Following year	Following year	Following year
Banvel/Clarity* dimethylamine salt of dicamba/diglycolamine salt of dicamba	Following treated crop harvest	Following treated crop harvest	Following treated crop harvest

Bronate (bromoxynil octanoate plus MCPA, 2-ethyl hexyl ester)	30 days	30 days	30 days
Buctril (octanoic acid ester of bromoxynil)	30 days	30 days	30 days
Canvas** (thifensulfuron methyl plus tribenuron methyl plus metsulfuron methyl)	10-34 months	10-34 months	10-15 months
Curtail** (2,4-D triisopropanolamine plus clopyralid)	10.5-18 months	18 months	18 months
Discover (clodinafop-propargyl)	12 months	12 months	12 months
Diuron* (diuron)	1-2 years	1-2 years	1-2 years
Everest (flucarbazone-sodium)	Not listed	12 months	11 months
Express (tribenuron methyl)	45 days	45 days	45 days
MCPA*	30 days to 3 months	30 days to 3 months	0 days to 3 months
Finesse** (metsulfuron methyl plus chlorsulfuron)	Successfully complete field bioassay	36 months	24 months
Glean** (chlorsulfuron)	Successfully complete field bioassay	36 months	24 months
Harmony Extra (thifensulfuron-methyl plus tribenuron methyl)	45 days	45 days	45 days
Harmony GT (thifensulfuron methyl)	45 days	45 days	45 days
Hoelon (diclofop-methyl)	Not listed	Not listed	Not listed
Liberty (glufosinate-ammonium)	120 days	120 days	120 days
Maverick (sulfosulfuron)	17-22 months	22 months	17-22 months
Muster (ethametsulfuron)	22 months	22 months	22 months
Paramount*** (quinclorac)	24 months	24 months	24 months
Peak** (prosulfuron)	22 months	22 months	22 months
Puma (fenoxaprop-p)	Not listed	Not listed	Not listed
Starane (fluroxypyr 1-methylheptyl ester)	120 days	120 days	120 days
Stinger** (clopyralid, monoethanolamine salt)	12-18 months	18 months	18 months
Tordon*** (picloram, potassium salt)	Successfully complete field bioassay	Successfully complete field bioassay	Successfully complete field bioassay

* Labeled plant-back interval varies with specific product label.
** Labeled plant-back interval varies with soil pH, soil moisture, or soil organic matter content.
*** Must also successfully complete field bioassay. Actual safe plant-back interval will vary with soil conditions, moisture conditions, herbicide rate, crop species, and other factors.

The rotation of pulse crops with other crops is an integral part of the pre-plant pest control strategy. Pulses are best grown following a cereal rather than another crop that may harbor pulse diseases. Pulse crops are susceptible to diseases that can overwinter in the soil and in stubble. These considerations are important in management of weeds and diseases and in minimizing residual herbicide injury to the crop.

Pulse crops offer several agronomic and economic advantages for the producer. Cereal crop yields often increase when planted after legumes because cereal pest (disease, insect, and weed) cycles have been disrupted. Legume crops enable use of different herbicides than the cereal crops to clean up grassy weeds. The legumes conserve soil moisture and limit soil erosion by offering an option other than summer fallow. Finally, pulses increase the nitrogen content of the soil.

Chickpeas can be seeded into standing or tilled stubble and fallow. Lentils and dry peas emerge and perform well when planted in a variety of seedbeds but most are direct seeded into grain residue. They typically are grown following winter wheat or spring barley. Cereal stubble that is fall plowed or chiseled is cultivated for weed control then harrowed and rolled.

Weeds

Weed control is critical for good production of pulses as well as for the health of the subsequent crops in the rotation. Because they are slow to establish and produce limited vegetative growth, pulse crops are not very effective competitors with weeds. For this reason, growers avoid fields with a history of broadleaf perennial weed problems. Growers practice crop rotation, which may include chemical fallow, to decrease weed populations. Cultural practices to form a smooth, firm seedbed are used to reduce winter annual weeds. But seedbed preparation alone is not sufficient for management of annual weeds.

Control of annual weeds usually begins in the fall or spring prior to planting with non-selective herbicide applications or tillage operations followed by herbicide applications. Perennial weed control begins 1-3 years earlier with herbicide applications or tillage operations. Fall or spring pre-seeding tillage is used to control winter annual and biennial weeds and to activate some soil-incorporated herbicides. Spring tillage controls early-emerging, summer annual weeds. Shallow tillage avoids bringing weed seeds up near the soil surface where they are likely to germinate. Excessive tillage dries the seedbed making shallow seeding less effective; it also leads to soil erosion.

Weeds are also managed with stale seedbed techniques, such as delaying seeding, allowing weeds to emerge, and then destroying them with either tillage or a non-selective herbicide. These techniques are not foolproof, because weeds emerge throughout the growing season and warm-season annual weeds may be favored by delayed seeding. In addition, delayed seeding will diminish yield potential and quality.

Sowing pulses into clean fields is preferred, but pulses are frequently seeded on stubble, where potential weed competition is often high and can be complicated by volunteer plant growth. If pulse crops are directly seeded into stubble with reduced-tillage methods, the previous crop is very important. Volunteer canola or tame mustard is especially important to control as these can smother a pulse crop. Volunteer cereal control is important, as the seeds from any plants that escape can be difficult to separate from lentils. The move to direct seeding has reduced overall pesticide load, but pulse production still requires pesticide use to maintain yields. Direct seeding practices have reduced the weed seed bank, which in the long run may reduce the total herbicide load.

Few herbicides are registered for managing weeds in pulse crops, especially broadleaf weeds. Perennial broadleaf weeds like field bindweed and Canada thistle are not successfully controlled during the fall before seeding pulses, so problems must be addressed in preceding crops. Annual broadleaf weeds such as kochia and Russian thistle are not successfully controlled in small grains or fallow rotations before seeding pulses. Because of the tumbling nature of these weeds, they are likely to re-infest fields by wind movement.

Grass weeds are easier than broadleaf weeds to manage in pulses; rotating to pulse crops may improve grass weed management in small grains.

Besides reducing yields through competition, weeds present other problems in pulse production. Weeds can contribute exudates at harvest that stain pulses, reducing quality. Weeds also interfere with mechanical harvesting.

Specific Problem Weeds

Growing regions are broken down into four major areas, which are defined on the maps located at the beginning of this document.

Region 1 (warm, semiarid, Pacific Northwest)

<u>Perennials</u>: Canada thistle, field bindweed, quackgrass
<u>Annual Grasses</u>: *wild oat, *Italian ryegrass, *downy brome, *jointed goatgrass, *volunteer cereals
<u>Annual Broadleaves</u>: *brassicas (esp. mustard, pennycress), *prickly lettuce, dog fennel (mayweed chamomile), nightshades, kochia, common lambsquarters, pigweeds, **Gallium* spp., buckwheat, knotweed, cornflower, Russian thistle, Canada fleabane/horseweed
**winter annual biotypes*

Region 2 (cool, subhumid, Canadian Parkland)

<u>Perennials</u>: Canada thistle, quackgrass, perennial sow thistle, dandelions, clovers
<u>Annual Grasses</u>: *volunteer cereals, *wild oat
<u>Annual Broadleaves</u>: *brassicas (esp. mustard), *volunteer canola, *volunteer legumes, narrowleaf hawksbeard
**winter annual biotypes*

Region 3 (warm, semiarid, Northern Plains)

Perennials: Canada thistle, field bindweed, quackgrass, perennial sow thistle, dandelions, foxtail barley (perennial grass)
Annual Grasses: *wild oat, *downy brome, *Italian ryegrass, *jointed goatgrass, *volunteer cereals
Annual Broadleaves: *brassicas (esp. mustard, pennycress), *prickly lettuce, nightshades, kochia, common lambsquarters, pigweeds, **Gallium* spp,. buckwheat, knotweed, cornflower, Russian thistle, *Canada fleabane/horseweed, *volunteer canola, *volunteer legumes, *narrow leaf hawksbeard, *foxtail (green and yellow), *vetch, *Persian darnel, *Canada fleabane/horseweed, *wild buckwheat, *cow cockle, *wild sunflower
**winter annual biotypes*

Region 4 (warm, subhumid, Northern Plains)

Perennials: Canada thistle, field bindweed, quackgrass, perennial sow thistle, dandelions, foxtail barley (perennial grass)
Annual Grasses: *wild oat, *downy brome, *volunteer cereals
Annual Broadleaves: *brassicas (esp. mustard, pennycress), *prickly lettuce, nightshades, kochia, common lambsquarters, pigweeds, **Gallium* spp., buckwheat, knotweed, cornflower, Russian thistle, *Canada fleabane/horseweed, *volunteer canola, *volunteer legumes, *narrowleaf hawksbeard, *foxtail (green and yellow), *vetch, *Persian darnel, *wild buckwheat, *cow cockle
**winter annual biotypes*

Cultural Practices

Employment of certain cultural practices helps to control weeds. Use of clean equipment is an essential practice for all pulse growers. Selecting proper fields and being mindful of rotation (i.e., which crops were grown previously, which weeds were predominate, etc.) also helps. Growers find that extending rotations so that the legume crop is grown only once every three to four years helps keep weed populations more manageable.

The way in which fertilizer is used (i.e., timing, quantity, etc.) will affect growth of weeds as well as the crop. It is important that the pulse crop establish quickly and at an adequate density to compete successfully with emerging weeds.

Some practices control certain weeds while encouraging others; growers base their decisions on the circumstances specific to their field in a given year. For example, deep tillage can be useful in discouraging some weeds, while low-till or no-till methods discourage wild oat, nightshade, and green foxtail.

Removing crop residues through either field burning or silaging will remove much of the seed bank, but is not generally cost-effective.

While cultural practices confer many benefits, employment of cultural practices alone cannot effect complete weed control. Most weeds are managed by the use of integrated weed management, combining cultural practices with the judicious use of herbicides.

Direct-seed systems create heavy reliance on glyphosate, which may result in resistance. Herbicide-resistant crops complicate weed control. The potential release of Roundup-Ready wheat varieties means that control systems other than the current standard of applying glyphosate for pre-plant burndown will have to be developed. Also, the practice of controlling volunteer canola or cereals with imazethapyr or imazamox will not be effective on Clearfield or imidazolinone-resistant varieties.

Chemical Controls

In this section only, due to the relatively large number of chemical options (not all of which are effective), the variability between regions, and the differences between the three crops, chemical control strategies are presented in bulleted lists sorted by crop, then by region. See also Appendix B, Efficacy Tables for Herbicides, for specific information.

Chickpeas
Region 1:

- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged.
- Ethalfluralin (Edge, Sonalan) and pendimethalin (Prowl) are registered for buckwheat control, but herbicide carryover onto winter wheat that is planted within 6 months is unacceptable. In effect, nothing is available for buckwheat control.
- Imazethapyr (Pursuit) is most commonly used at the pre-plant stage for annual broadleaf weeds and some grasses but it may cause crop damage. Effective control is lost at reduced rates. Imazethapyr (Pursuit) is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters.
- Pendimethalin (Prowl), when applied in combination with imazethapyr (Pursuit), broadens the broadleaf control, but does not control wild oat or other grasses.
- Triallate (Far-Go, Avadex BW) is used only for wild oat control and must be incorporated twice.
- Metribuzin (Sencor, Lexone DF) is also used for control of annual broadleaf weeds. Pre-plant applications of metribuzin (Sencor, Lexone DF) do not provide effective control and result in crop damage if applied in areas with heavy moisture (1/2-inch rain within 48 hrs. of application).
- Dimethenamid (Frontier 6EC), which was recently registered for annual grasses and broadleaf, is weak on dog fennel.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not applied often because of plant-back restrictions on winter wheat.
- Trifluralin (Treflan) is labeled, but seldom used due to carryover and the need for incorporation.

Region 2:
No chickpeas grown in Region 2.

Region 3:
Canada

- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged.
- High rates of glyphosate (Roundup Ultra) are applied for foxtail barley and dandelion control.
- No other pre-plant herbicides are presently registered.
- Controlling volunteer Round-up Ready canola is a concern.

U.S.

- Imazethapyr (Pursuit) is not used in Montana, due to crop injury potential based on low soil organic matter and low moisture. Imazethapyr (Pursuit) is used in North Dakota.
- Sulfentrazone (Spartan), a key herbicide for kochia, Russian thistle, pigweed, and wild buckwheat, is used in Montana, North Dakota, and South Dakota under a Section 18, but it only provides suppression for wild buckwheat.
- North Dakota does not have registrations for metribuzin (Sencor, Lexone) or dimethenamid (Frontier 6EC).
- DNAs are used for a narrow spectrum of broadleaf weeds and some grassy weeds. They do not sufficiently control mustards, kochia, Russian thistle, or wild buckwheat. Downy brome control is important.
- Ethalfluralin (Edge, Sonalan) and trifluralin (Treflan) labels require two incorporations, therefore these options don’t fit into low-till or no-till systems.
- Pendimethalin (Prowl) and sulfentrazone (Spartan) must be incorporated with rain (which doesn’t always occur timely).

Region 4:
Very few chickpeas are grown in Region 4.

Lentils

Region 1:

- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged. In effect, nothing is available for buckwheat control.
- Pendimethalin (Prowl) is registered for buckwheat control, but carryover of herbicide is unacceptable because winter wheat is planted within 6 months.

- Imazethapyr (Pursuit) is most commonly used at the pre-plant stage for annual broadleaf weeds and some grasses but may cause crop damage. Reduced rates do not provide effective control. It is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters.
- Pendimethalin (Prowl) is applied in combination with imazethapyr (Pursuit). It broadens the broadleaf control but does not control wild oat and other grasses.
- Triallate (Far-Go, Avadex BW), which uses a different mode of action, is used only for wild oat control, but controls no other species and must be incorporated twice.
- Metribuzin (Sencor, Lexone DF) is also used on annual broadleaf weeds. Pre-plant applications are not very effective and result in crop damage with heavy moisture (1/2 inch rain within 48 hrs. of application).
- S-metolachlor (Dual Magnum, Dual II Magnum) is not used very often because of plant-back restrictions on winter wheat.

Region 2:
Very few lentils are grown in Region 2.

Region 3:
Canada
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged.
- High rates of glyphosate (Roundup Ultra) are applied for foxtail barley and dandelion control.
- No other pre-plant herbicides are registered.
- Controlling volunteer Round-up Ready canola is a concern.
- Trifluralin (Treflan) and ethalfluralin (Edge, Sonalan) are also used (fall application only), but the requirement for incorporation dries out the seedbed.
- Metribuzin (Sencor, Lexone DF) is used and may be tank-mixed with trifluralin (Treflan) in spring applications only.

U.S.
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged.
- High rates of glyphosate (Roundup Ultra) are applied for foxtail barley and dandelion control.
- Imazethapyr (Pursuit) is not used in Montana, due to crop injury potential based on low soil organic matter and low moisture. Pursuit is used in North Dakota.
- North Dakota and Montana do not have registrations for ethalfluralin (Edge, Sonalan).

- S-metolachlor (Dual Magnum, Dual II Magnum) is not registered for North Dakota.
- DNAs are used for a narrow spectrum of broadleaf weeds and some grassy weeds. They do not sufficiently control mustards, kochia, Russian thistle, or wild buckwheat. Downy brome control is important.
- Trifluralin (Treflan) is only labeled for two incorporations, therefore it doesn't fit into low-till or no-till systems.
- Pendimethalin (Prowl) must be incorporated with rain (which doesn't always occur timely).

Region 4:
Few lentils are grown in Region 4.

Dry Peas

Region 1:
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, prickly lettuce, or any annual weed not yet emerged. In effect, nothing is available for buckwheat control.
- Pendimethalin (Prowl) and Ethalfluralin (Edge, Sonalan) are registered for buckwheat control, but herbicide carryover is unacceptable because winter wheat is planted within 6 months.
- Imazethapyr (Pursuit) is most commonly used at the pre-plant stage for annual broadleaf weeds and some grasses but may cause unacceptable crop damage. Reduced rates do not provide effective control. It is weak on wild oat, dog fennel, prickly lettuce and common lambsquarters.
- Pendimethalin (Prowl), applied in combination with imazethapyr (Pursuit), broadens the broadleaf control, but does not control wild oat and other grasses.
- Triallate (Far-Go, Avadex BW), which uses a different mode of action, is used only for wild oat control, but controls no other species and must be incorporated twice.
- Metribuzin (Sencor, Lexone DF) is applied for annual broadleaf weed control. Pre-plant applications are less effective and result in crop damage with heavy moisture (1/2 inch rain within 48 hrs. of application).
- Dimethenamid (Frontier 6EC) was recently registered for annual grasses and broadleaf weeds, but it is weak on dog fennel.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not used very often because of plant-back restrictions on winter wheat.
- Trifluralin (Treflan) is labeled, but is seldom used because of carryover and need for incorporation.
- Pronamide (Kerb) is labeled for pre-plant on winter peas but is not used because of excessive cost and carryover potential.

Region 2:

- Glyphosate (Roundup Ultra) is used, as are ethalfluralin (Edge), trifluralin (Treflan), and metribuzin (Sencor).
- Ethalfluralin (Edge), trifluralin (Treflan), and/or metribuzin (Sencor) can be applied spring or fall, but are best applied in fall. This timing can lead to erosion concerns.
- Amitrole (Amitrol) is registered but has limited use because of the length of the pre-plant interval. It effectively controls dandelion.

Region 3:

Canada

- Glyphosate (Roundup Ultra) is used, as are ethalfluralin (Edge), trifluralin (Treflan), and metribuzin (Sencor).
- Ethalfluralin (Edge), trifluralin (Treflan), and/or metribuzin (Sencor) can be applied spring or fall, but are best applied in fall. This timing can lead to erosion concerns.
- Amitrole (Amitrol) is registered but has limited use due to length of pre-plant interval. It effectively controls dandelion.

U.S.

- Imazethapyr (Pursuit) is used but it is not labeled for use in North Dakota.
- Sulfentrazone (Spartan), a key herbicide for kochia, Russian thistle, pigweed, and wild buckwheat, is used in Montana, North Dakota and South Dakota under a Section 18 exemption. Preliminary damage reports for dry pea necessitate use rate changes.
- Glyphosate (Roundup Ultra) is used, as are ethalfluralin (Edge), trifluralin (Treflan), and metribuzin (Sencor).
- DNAs are used for a narrow spectrum of broadleaf weeds and some grassy weeds, but do not sufficiently control mustards, kochia, Russian thistle, or wild buckwheat. Downy brome control is important.
- Ethalfluralin (Sonalan) and trifluralin (Treflan) labels require two incorporations, therefore these options don't fit into low-till and no-till systems.
- Pendimethalin (Prowl) and sulfentrazone (Spartan) must be incorporated with rain (which doesn't always occur timely).
- Paraquat is registered but not used due to excessive cost.

Region 4:

Canada

- Glyphosate (Roundup Ultra) is used, as are ethalfluralin (Edge), trifluralin (Treflan), and metribuzin (Sencor).
- Ethalfluralin (Edge), trifluralin (Treflan), and/or metribuzin (Sencor) can be applied spring or fall, but are best applied in fall. This timing can lead to erosion concerns.

- Amitrole (Amitrol) is registered but has limited use due to length of pre-plant interval. Good efficacy on dandelion.

U.S.
- Imazethapyr (Pursuit) is used but it is not labeled for use in North Dakota.
- Sulfentrazone (Spartan), a key herbicide for kochia, Russian thistle, pigweed, and wild buckwheat, is used under a Section 18 exemption in Montana, North Dakota, and South Dakota. It is labeled for suppression only of wild buckwheat.
- Glyphosate is used, as are ethalfluralin (Edge), trifluralin (Treflan), and metribuzin (Sencor).
- DNAs are used for a narrow spectrum of broadleaf weeds and some grassy weeds, but do not sufficiently control mustards, kochia, Russian thistle, or wild buckwheat. Downy brome control is important.
- Ethalfluralin (Sonalan) and trifluralin (Treflan) are only labeled for two incorporations, therefore these options don't fit into low-till and no-till systems.
- Pendimethalin (Prowl) and sulfentrazone (Spartan) must be incorporated with rain (which doesn't always occur timely).
- Paraquat is registered but not used due to excessive cost.

Critical Needs for Management of Weeds in U.S. and Canadian Pulse Crops Pre-Plant:

Research
U.S. and Canada
- *Develop improved management options at the pre-plant or pre-emergence stage for buckwheat, kochia, Russian thistle, prickly lettuce, vetch, Round-up Ready canola, and dog fennel*
- *Investigate herbicides with new modes of action*
- *Develop methods of application, including timing and rates, to allow existing compounds' use on pulses and rotational crops*
- *Investigate glyphosate tank-mixes for broader-spectrum weed control*
- *Investigate carryover of fall-applied phenoxy compounds on pulses*
- *Improve perennial weed management options*
- *Investigate interaction of chemical controls with soil organic matter/pH*
- *Improve winter annual broadleaf control in winter pea and lentil*
- *Explore pro's and cons of breeding (conventional or otherwise) for herbicide tolerance*

Regulatory
Canada

- *Expand DNA labels to include surface application*
- *More chemical control choices needed; harmonize with U.S. registrations where appropriate data exists in cooperation with registrants*
- *Explore possibility of growers, registrants, and regulators discussing growers' waiver of liability; acceptance of farmer-generated data (e.g., within the context of pest groupings)*

U.S.
- *Expedite full sulfentrazone (Spartan) registration (all states) for chickpea*
- *Improve definition of crop groupings*
- *Distinguish or consider grouping winter and spring biotypes*
- *Re-evaluate the validity of current field trial regions*
- *Evaluate the possibility of relief from certain data requirements for minor use situations and label extensions/additions*

Education

U.S. and Canada
- *Develop crop profiles*
- *Educate growers on persistence of herbicides in soil*
- *Educate funding sources on the need for more applied research*
- *Conduct field days for regulators to encourage hands-on familiarity with crops and grower issues*
- *Work with registrants on needs*

Diseases

Chickpeas, lentils, and dry peas are infected by a number of fungi that can cause seed, seedling, and root diseases. These diseases may result in reduced germination, stand establishment, and seed yield and quality. Seed infected shortly after planting may fail to emerge or damp-off soon after emergence. Seedling blight pathogens may also attack adult plants, resulting in reduced leaf and pod development. Fungi causing root rots and seedling blights may affect all pulse crops, predominantly when growing conditions in spring are adverse due to low temperatures, high precipitation, water-logged soils, or drought.

Three primary fungi types are involved in causing seed and root rots: *Rhizoctonia*, *Fusarium*, and *Pythium* species. These fungi can survive in the soil and spread if environmental conditions remain conducive over several seasons. While primarily soil-borne, these fungi are also present in crop residue and dust of contaminated seed lots. In some areas soil-borne *Aphanomyces euteiches* causes serious root rot in pea.

The pathogen causing ascochyta blight can also over-winter in pulse seed or residue. Ascochyta blight infects all pulses but each crop type is infected by a different *Ascochyta* species. (This is discussed in greater detail in the "Emergence to Harvest" section, below.) Among the pulse crops, chickpea is most severely affected by ascochyta blight and this disease is a key limiting factor to production in North America. Other significant seed- and residue-borne diseases include sclerotinia (*Sclerotinia sclerotiorum*), botrytis gray mold (*Botrytis cinerea*), and anthracnose of lentil (*Colletotrichum truncatum*).

Cultural Practices

In Canada, it is recommended that pulse growers have their seed tested at an accredited laboratory to determine the percentage of seed-borne disease and germination. Seed-borne disease tests are available for ascochyta blight, sclerotinia, and botrytis in all pulses and anthracnose in lentil. Depending on the level of seed-borne disease, the type of pulse crop and percent germination, it may be recommended to not use the seed for planting or to use a fungicide seed treatment.

Pulse growers select vigorous cultivars that are best suited to their climatic region and have the highest level of disease resistance available. There are no cultivars with resistance to diseases caused by Fusarium, Rhizoctonia, Botrytis, Sclerotinia, Pythium or *Aphanomyces* species. Pea cultivars vary in their tolerance to ascochyta blight. There are some lentil cultivars available in Canada with resistance to ascochyta blight and anthracnose. There are some chickpea and lentil cultivars available in the United States with partial resistance to ascochyta blight and breeding efforts are underway to identify improved resistance.

Crop rotation with cereals is important to reduce the level of seed- and residue-borne pathogens. However, rotation with non-host crops will not eliminate seed and root rot disease since these pathogens remain viable in the soil for several years and can infect other crops. Growers plant the same type of pulse crop only once every four years in a field to allow residues to decompose and pathogen numbers to fall off. Other residue management practices such as straw chopping, burial or burning may be considered.

In addition, agronomic practices such as seedbed preparation, seed handling, date of planting, row spacing, *Rhizobium* inoculation for nitrogen fixation, and weed control are part of cultural control of disease at the pre-plant stage.

Chemical Controls

In Canada, mefenoxam (Apron XL, Allegiance FL) is registered in pea, chickpea and low tannin lentils as a seed treatment against Pythium species, and in particular, Kabuli chickpea seed is regularly treated. Carbathiin/thiabendazole (Crown) is registered in lentil and chickpea against seed-borne ascochyta blight, but will also protect against other seed- and root-rotting fungi. Several fungicides are registered in peas as seed treatments against seed and root rots: Captan/diazinon/lindane (Agrox), captan (Captan FL), thiram (Thiram 75WP), and carbathiin/thiram (Vitaflo-280). Among these, Vitaflow-280 and Thiram 75WP are most commonly used in Canada.

In the United States, Captan (Captan 400) is applied as a seed treatment, usually in combination with mefenoxam (Apron XL). Captan use has decreased over the past few years but continues to be a very effective broad-spectrum fungicide, especially for the control of seedling rot. In the United States, fludioxonil (Maxim) + mefenoxam (Apron XL) is applied as a seed treatment. Fludioxonil provides good control of seedling rot and damping-off from Rhizoctonia and Fusarium, while Pythium is controlled by mefenoxam. No fungicide is available for seed treatment against *Aphanomyces euteiches*. In the United States, seed-borne ascochyta blight is controlled with a Section 18 emergency exemption for thiabendazole (LSP, Mertect).

Critical Needs for Management of Diseases in U.S. and Canadian Pulse Crops Pre-Plant:

Research

U.S. and Canada

- *Breeding for disease-resistant varieties*
- *Investigate residue-associated disease management*
- *Investigate possibility of pre-plant disease control (improved seed treatment, biologicals, etc.)*
- *Investigate implications of cropping practices (e.g., residue management, rotations) crop sequencing, systems, and rotations on disease incidence and severity*
- *Investigate effect of soil fertility on disease*

Regulatory

U.S.

- *Relax regulation of field burning as an alternative during transition*

U.S. and Canada

- *Resolve potential regulatory issues with some fungicide seed treatments*

Education

U.S. and Canada

- *Educate research funding sources about the importance of supporting plant breeding*
- *Educate growers about residue/stubble management alternatives*
- *Educate growers on disease management*

Insects

In general, insects are not a significant pre-plant problem in pulse crops. At the pre-plant stage, growers can use available forecasting models to plan for insect control in later crop stages.

Cultural Practices

Field selection and crop rotations can affect insect pressure. Adjacent alternate hosts are evaluated and controlled where necessary in southern Alberta.

Chemical Controls

No insecticides are applied at the pre-plant stage.

Critical Needs for Management of Insects in U.S. and Canadian Pulse Crops Pre-Plant:

Research

U.S. and Canada

- *Research potential problem of alternative hosts adjacent to pulse fields*
- *Pursue novel and alternate means of control through prevention*
- *Improve forecast models for various insects*

Regulatory

U.S. and Canada

- *Support registration of novel and alternate means of control through prevention*

Education

U.S. and Canada

- *Expand use of forecast maps by educating growers on their use*

Planting

Lentils, dry peas, and desi chickpeas are cool-season crops that can be seeded early into cool soils (40°F, 5°C); kabuli chickpeas require warmer soils (46-50° F, 8-10°C). The rate at which the soil warms affects early crop vigor, which in turn affects the plants' tolerance of weeds and diseases.

Pulse crops can be planted under conventional, minimum-till, or no-till production systems.

Direct seeding techniques and low-till/no-till techniques can be very effective for pulse production. Extended rotations are especially important in direct seeding to reduce the spread of disease from intact residues on the soil surface and to allow for a slower breakdown of residual herbicides. Pulse crops generally follow winter wheat or spring barley. Cereal stubble that is fall plowed or chiseled is cultivated for weed control and herbicide incorporation, then harrowed and rolled. The rolling of pulses after planting is a field operation used to smooth the soil surface to improve the harvesting of low-hanging pulse pods. Rolling may be done anytime from immediately after seeding up to the 5- to 7-node stage in lentils and up to the 5-leaf stage in dry peas. Chickpeas are rolled prior to emergence only. Maintaining firm seed-to-soil contact is critical, so pulses should be seeded into moist soil and dry soil should be avoided. Growers try to avoid excessive tillage in the spring to prevent drying out the seedbed.

Most pulse seeds can emerge from deep seeding depths due to their large size. However, deep seeding is not required, provided that the seed is accurately placed in firm, moist soil. Lentils should be seeded more than 2 inches deep to minimize herbicide-leaching damage to seedlings if metribuzin (Sencor, Lexone DF) is applied. Seeding depth is also determined by herbicide incorporation depth. In direct-seeding systems, the seed is placed at a shallow depth compared to pre-tilled soils, as soil moisture is usually much higher in untilled soils.

There are a few drawbacks to direct seeding and low-till/no-till techniques. Pulse crops grown under these systems have a greater reliance on non-selective herbicides such as glyphosate (Roundup Ultra). Some herbicides require incorporation into the soil, an option that is limited with these production methods. Also, the untilled residues remaining on the soil surface from the previous crop may tie up residual herbicides, rendering them ineffective.

At the same time, direct seeding and low-till/no-till methods have distinct advantages. Mulch from surface residue changes surface ecology; soil aeration changes, which in turn facilitates water pass-through and favors certain organisms. The resulting improved soil tends to promote plant health, and healthy plants are better able to resist pest pressure.

Weeds

The use of clean seed is an effective tactic to avoid introducing new weed species into fields. Using clean seed prevents the introduction of wild tomato and other members of the nightshade family. The seeds of these weeds can stick to pulse seeds and since the fruits can be similar size to pulses, they may not be removed by standard cleaning procedures.

The timing of seeding can affect weed competition. Weeds that emerge with or before the crop have a greater effect on the crop than those that emerge later. Early seeding may allow the crop to get a head start before the weeds emerge. This is especially true for weeds such as green foxtail that require warm soil for germination and in low-till and no-till systems where there is little or no general soil surface disturbance to encourage early weed germination. Delayed seeding is 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. However, delayed seeding generally reduces quality and yield. Non-selective pre-emergent herbicides create the same advantage as pre-emergent tillage by clearing the field as the small crop seedlings emerge.

Cultural Practices

Pulse growers use clean, weed-free seed. Many use certified seed, which is weed-free and also results in greater vigor. Optimal seeding rate, timing, spacing, and depth also help ensure a vigorous crop. Strong, early emergence is important in achieving a heavier canopy and increasing the plants' ability to out-compete weeds. Starter fertilizer is often banded at or near the seed planting to assist in early vigor.

Chemical Controls

No herbicides are applied at planting. The planting system chosen (conventional or direct seeding) will affect chemical control options later in the crop cycle.

Critical Needs for Management of Weeds in U.S. and Canadian Pulse Crops at Planting:

Research

U.S. and Canada

- *Develop a leafy pea that stands upright (erect habit) for improved weed competitiveness*

Regulatory

- *None*

Education

- *None*

Diseases

During the cropping season, chickpea, lentil, and dry pea can be infected by fungi that cause ascochyta blights, anthracnose, sclerotinia white mold, botrytis gray mold, and powdery mildew. Root rots and seedling blights can continue to affect pulse crops during the season. For details see "Diseases" under the "Pre-Plant" section, above.

Critical Needs for Management of Diseases in U.S. and Canadian Pulse Crops at Planting:

Research

U.S. and Canada

- *Additional research needed for seed treatments, e.g., control of root diseases*
- *Investigate epidemiology of seed-borne pathogens*
- *Develop biological-based control for Pythium (damping off) in chickpea*
- *Investigate fungicide-inoculant-solubilizer interactions*

- *Develop cost-effective quantitative PCR (polymerase chain reaction) method for pathogen detection in seed*

Regulatory
U.S.
- *Obtain a federal label for thiabendazole (LSP)*

Canada
- *Obtain a federal label for thiabendazole (Mertect) as a seed treatment*

Education
U.S. and Canada
- *Educate growers on specific seed treatments and application techniques*
- *Continue to educate growers about agronomic practices*

Insects

Wireworm (*Limonius* spp.) larvae and seed corn maggots feed on germinating seeds and seedling dry pea and lentil plants and can thin or destroy stands. The wireworm larvae typically take several years to develop. They cause little damage the first year but feed heavily thereafter, cutting off and damaging roots. Wireworm density and injury to lentils are directly related to soil moisture. Wireworms are generally low in years of average or below average precipitation, and high and damaging in years of above average precipitation.

Cultural Practices

Growers use soil tests to determine wireworm populations. The presence of three or more wireworms per square foot signals that control measures are needed.

Chemical Controls

Lindane has historically been applied in the Pacific Northwest and Montana as a seed treatment to some seed, usually in combination with fungicides, but at present it is under scrutiny. Growers are in the process of transitioning away from lindane entirely. Canadian growers do not use lindane on pulse crops.

Critical Needs for Management of Insects in U.S. and Canadian Pulse Crops at Planting:

Research
U.S.
- *Develop alternative controls for wireworm*
- *Develop longer-term systemic seed control for later insects*

Canada

- *Research needed specifically in chickpea for wireworm, as no controls are registered*

Regulatory

U.S.

- *Registration is needed for products to replace lindane, such as imidacloprid and/or thiamethoxam*

Canada

- *Expedite registration of wireworm control products in chickpea*

Education

- *None*

Pre-Emergence

After planting, pulse crop beds are rolled to smooth the soil surface. This field operation improves the harvesting of low-hanging pulse pods by reducing harvest losses and breakage of sickle section and guards, and improves harvest rate. Rolling is done anytime from immediately after seeding up to the 5- to 7-node stage in lentils and up to the 5-leaf stage in peas. Chickpeas are rolled prior to emergence only.

Weeds

Pulse crops are weak competitors with weeds. Limited herbicide choices and increased annual and perennial weed densities, resulting from volunteer crops as weeds and the increased importance of winter annuals and secondary weed competitors, present special weed control challenges. Weed control at the pre-emergence stage is important to help encourage vigorous seedling growth for effective competition.

Chemical Controls

Metribuzin (Sencor) is applied pre-emergent on a few acres of lentils when weed control is not achieved by the pre-plant incorporated herbicides. It can cause crop stress under high-precipitation weather conditions.

Other herbicides that are applied pre-emergent include dimethenamid (Frontier 6EC), imazethapyr (Pursuit), and s-metolachlor (Dual Magnum, Dual II Magnum).

Critical Needs for Management of Weeds in U.S. and Canadian Pulse Crops at Pre-Emergence:

Research

U.S. and Canada

- *Determine optimal timing and method of application of weed control product*
- *Investigate pre-emergent annual broadleaf control in chickpeas and lentils*
- *Investigate mechanical methods of weed control*
- *Research expansion of herbicide use during the fall for winter legumes*

Regulatory

U. S. and Canada

- *Expand Pursuit label, harmonization for all 3 crops*
- *Register label for sulfentrazone (Spartan) on dry peas and chickpeas*
- *Work with registrants to maintain active ingredient registrations*
- *Note that registrant response time is slow due to consolidation of registrants*

Canada

- *Register label for ethalfluralin (Edge) on chickpea*
- *Register label for trifluralin (Treflan) on chickpea*

Education

U.S. and Canada

- *Educate registrants on our registration priorities; work with them to maintain active ingredient registrations*

Diseases

Seedling blights, root rots, botrytis gray mold, and seed-borne ascochyta blight can infect pulse crops at pre-emergence. For details see "Diseases" under the "Pre-Plant" section, above.

Critical Needs for Management of Diseases in U.S. and Canadian Pulse Crops at Pre-Emergence:

Research

U.S. and Canada

- *Screen germplasm for resistance to damping off and root rot (Pythium and Rhizoctonia)*

Regulatory

- *None*

Education

- *None*

Insects

Insects are not controlled at the pre-emergent stage.

Vertebrates and Other Non-Insect Pests

The primary means by which vertebrates affect pre-emergent pulse crops is eating the seeds. Geese eat seeds near the surface while various voles and the Richardson ground squirrel dig for sub-surface seeds.

Critical Needs for Management of Vertebrates and Other Non-Insect Pests in U.S. and Canadian Pulse Crops at Pre-Emergence:

Research

U.S. and Canada

- *Investigate biological (non-chemical) seed treatment with repellent properties*

U.S.

- *Research bird repellents to replace lindane*

Regulatory

- *None*

Education

- *None*

Emergence to Harvest

Pulse crops have a prostrate growth habit and low pod set. This affects the practicality of mid- to late-season mechanical pest control and often necessitates specialized attachments for combine headers to allow mechanical harvest. Commonly, lentils are swathed prior to harvest due to uneven maturity or weed infestation, which also requires specialized combine attachments. Dry peas and chickpeas may be swathed prior to harvest, but this is less common.

Weeds

During the emergence-to-harvest phase, pulse crops compete poorly with weeds because pulse crops' seedlings grow slowly, the plants have a low stature, and the growth habit does not effectively close the crop canopy. Weed control is hampered by limited herbicide choices. Both annual and perennial weed densities have increased over time in all pulse growing regions, resulting from volunteer crops as weeds and the increased importance of winter annuals and secondary weed competitors. Grass and broadleaf weeds are a very serious problem in pulse production. Typical troublesome weeds include wild oats, various mustards, nightshades, pigweed, common lambsquarters, prickly lettuce, pineapple weed, field pennycress, field bindweed, Russian thistle, and mayweed chamomile.

Cultural Practices

Fields are inspected repeatedly during the growing season to determine weed populations. Field histories are important in predicting weed populations in a given field. The weeds in a pulse crop are generally similar to those experienced in previous years in the same field in cereal crops. Mechanical weed control from mid to late season is impractical due to the prostrate growth habit of the plants.

Chemical Controls

Post-emergent chemical controls in dry peas include metribuzin (Sencor) to control mayweed chamomile and common lambsquarters, and bentazon (Basagran) for excellent control of pineapple weed and mayweed. Bentazon (Basagran) is not usually applied to entire fields, but is useful on small sections of fields in controlling weeds in lower, wet areas without causing injury to peas. It is a contact herbicide applied in dry pea crops. Bentazon (Basagran) requires good leaf contact for best results and must be applied during active weed growth. Quizalofop (Assure II) is applied post-emergence to dry peas to control grass weeds such as wild oats, volunteer cereals and other annual and perennial grasses. Fluazifop-p-butyl (Fusion, Venture) is a systemic herbicide that is used at the post-emergence crop stage. It is most efficacious when applied while the weeds are small and actively growing. Early application of fluazifop-p-butyl (Fusion, Venture) is required because it has a pre-harvest interval (PHI) of 75 days in peas and 82 days in lentils.

Metribuzin (Lexone DF, Sencor) is a systemic post-emergent herbicide that kills susceptible plants by inhibiting photosynthesis. It is applied post-emergent on a few acres of lentils when weed control is not achieved by the pre-plant incorporated herbicides. This chemical has some foliar activity, but when applied post-planting, rain is necessary to move it down to the root zone of weeds. However, excessive rainfall can move metribuzin (Lexone DF, Sencor) deeper into the soil where it can cause injury to lentil plants that are sown less than two inches deep or on soil that has low levels of organic matter.

Other herbicides registered in lentils include the grass herbicides pendamethalin (Prowl), sethoxydim (Poast), and quizalofop (Assure II). Growers not using a preplant application of triallate (Far-Go, Avadex BW) will apply quizalofop (Assure II) postemergence. Postemergent use of quizalofop (Assure II) or sethoxydim (Poast) has the advantage of controlling weeds on an “as needed” basis. Another benefit is that these two herbicides exhibit little or no phytotoxicity.

Herbicide resistance is a serious concern of pulse growers. Many herbicide-resistant weeds have been found in all the pulse growing areas. Repeated use of a given product or of products with similar chemistries or modes of action contributes to resistance development; growers avoid this where possible, but chemical control options are limited in number. Saskatchewan growers have identified herbicide-resistant weeds in their region (Table 2); this table illustrates the nature of the problem present in all of the pulse-growing regions.

TABLE 2. Herbicide-resistant weeds in Saskatchewan

WEED	DESCRIPTION
Wild Oat, Green Foxtail	Resistant to a group of herbicides, which include Achieve, Affirm, Assure II, Champion Plus, Fusion, Hoe-Grass II, Horizon, Poast, Poast FlaxMax, Puma, Select, Triumph Plus, Prevail, Venture.
Kochia, Russian Thistle, Chickweed	Resistant to Ally, Amber, Assert, Express, Glean, Laser DF, Refine Extra, Triumph Plus, Pursuit (Chickweed).
Wild Mustard	Resistant to Ally, Amber, Assert, Express, Glean, Muster, Pursuit, Refine Extra.
Green Foxtail	Resistant to trifluralin products (Bonanza, Rival, Treflan) and to Edge and Fortress.
Wild Mustard	Resistant to 2,4-D, MCPA, Attain, Banvel, Caliber, Cobutox, Compitox, Curtail, dichlorprop-D, DyVel DS, Embutox, Estaprop, Mecoprop, Poast FlaxMax, Prevail, Target, Tordon, Triumph Plus, Tropotox Plus, Turboprop.

Critical Needs for Management of Weeds in U.S. and Canadian Pulse Crops from Emergence to Harvest:

Research

U.S. and Canada

- *Develop post-emergent control of broadleaf weeds in chickpeas, lentils, and peas*
- *Investigate herbicide resistance management*
- *Develop new chemistries to replace imidazolinones*
- *Investigate timing of post-emergent applications in winter legumes*
- *Investigate tank-mix combinations used for ascochyta blight, as well as combinations for herbicides and fungicides*
- *Develop plant varieties that can compete effectively with weeds*
- *Investigate annual sow thistle control in field peas*
- *Investigate Canada thistle control in pulses*
- *Develop application methods using wick applicators*

Regulatory

U.S. and Canada

- *Harmonize pesticide registrations*

U.S.

- *Seek expansion of current 24(c) registration of pyridate (Tough) to full national registration*

- *Expand imazethapyr (Pursuit) label, harmonize on all 3 crops*
- *Register label for sulfentrazone (Spartan) on dry peas and chickpeas*
- *Note that registrant response time is slow due to consolidation of registrants*

Canada
- *Register label for ethalfluralin (Edge) on chickpea*
- *Register label for trifluralin (Treflan) on chickpea*
- *Register label for pyridate (Tough) on chickpea*

Education
U.S. and Canada
- *Educate growers, general public, and regulators on the realistic expectations of speculative tactics ("silver bullet" and untested approaches to weed control)*

Diseases

For additional detail, refer to the "Diseases" sections under "Pre-Plant" and "Planting," above.

Ascochyta blights in chickpea, lentil, and pea are biologically similar, but the fungi causing these diseases are actually different in the three crops: *Ascochyta rabiei* in chickpea, *Ascochyta fabae* f. sp*. lentis* in lentil, and *Mycosphaerella pinodes* in pea (the condition resulting from the latter pathogen is sometimes more correctly called mycosphaerella blight). In Canada, two other pathogens causing similar symptoms in dry peas are considered to be of minor importance: *Ascochyta pinodella* causes foot rot and symptoms on the lower pea stem, and *Ascochyta pisi* infects all above-ground pea plant parts.

Generally, ascochyta blight affects all above-ground plant parts and can cause serious yield and quality loss. Symptoms usually include a tan lesion surrounded by a darker brown margin. Small, dark fruiting bodies called pycnidia are often visible within the lesions.

The major sources of ascochyta blight inoculum are infected seed and infected crop residue from previous crops. During the season, the pathogen is spread by water-splashed asexual spores (conidia), but *M. pinodes* in pea, and *A. rabiei* in chickpea can also produce airborne sexual spores (ascospores).

Anthracnose in lentil, caused by the fungus *Colletotrichum truncatum*, is a serious disease in southern Saskatchewan and in Manitoba. Symptoms on plants are similar to ascochyta blight but can often be distinguished by early leaf drop and the development of deep stem lesions that girdle the plant and cause severe die back. Disease management strategies are similar to those for ascochyta blight.

Sclerotinia white mold (*Sclerotinia sclerotiorum*) and botrytis gray mold (*Botrytis* spp.) are not specific to the pulses but infect a wide range of crops. They are mainly observed in rainy, wet years in the closed canopy of crops. Botrytis gray mold is seed-borne and infected seed can lead to seedling blight. Botrytis infection later in the season causes flower abortion and pod rot. Sclerotinia white mold causes mold on stems, leaves and pods. No fungicides are registered against these two diseases and no resistant varieties are available in Canada.

Powdery mildew caused by *Erysiphe pisi* is another disease found on pea but its importance is in decline due to the availability of varieties with complete resistance to the fungus. In contrast to most other diseases, powdery mildew thrives in hot and dry weather. Symptoms are a powdery white layer on the leaf and stem surface. The fungus can grow very quickly and cover the entire plant within a few days. Early infection (i.e., in late June or early July) often leads to yield loss and warrants a fungicide application. Late infection may not affect yield but often hampers harvest because the desiccant is not able to penetrate through the layer of white fungal material and the plants do not dry up well.

At least 27 different varieties of viruses have been identified in pulse crops. Viruses including pea enation mosaic virus (PEMV) and bean (pea) leaf roll virus (BLRV) affect pulses and are frequently vectored by the pea aphid from alternate host legumes. Virus control is strongly linked to pea aphid control, which is covered in the "Insects" section following.

Cultural Practices

Some general rules growers follow for ascochyta blight management in pulses are: a four-year crop rotation (i.e., three years between the same type of pulse crop), selection of cultivars with highest levels of resistance available, selection of clean seed that has been tested in an accredited seed testing lab, and regular scouting.

Chemical Controls

In Canada, chlorothalonil (Bravo 500) is the only foliar fungicide that has full registration in all pulse crops (as of summer 2002). It is registered for the control of ascochyta blight in chickpea, lentil, and pea and for anthracnose in lentil. Mancozeb (Dithane DG) is registered in lentil for the control of ascochyta blight and anthracnose. Sulfur (Kumulus DF) is registered in pea against powdery mildew in Canada. In Canada, fungicide application is usually not economical in pea, but returns in lentil and chickpea are usually high enough to allow the use of fungicides.

In the United States, azoxystrobin (Quadris) received an emergency registration for the control of ascochyta blight in chickpea in 2001 and 2002. (Full registration was announced in April 2003.)

Registration of pyraclostrobin (Headline) was announced in March 2003 in both Canada and the United States. This was one of the first protectants to be processed as a joint (international) label.

Critical Needs for Management of Diseases in U.S. and Canadian Pulse Crops from Emergence to Harvest:

Research

U.S. and Canada

- *Develop better control measures for ascochyta blight*
- *Develop a predictive model for treatment timing of ascochyta, sclerotinia (white mold), powdery mildew, botrytis, and anthracnose*
- *Monitor resistance in plant pathogen populations*
- *Investigate fungicide application techniques*
- *Conduct further research into fungicide regimes (how to utilize sequential applications with available fungicides)*
- *Develop a model of disease development as a risk management tool for growers*

Regulatory

U.S. and Canada

- *Allow multiple section 18 exemptions from registrations for resistance management purposes*

Education

U.S. and Canada

- *Educate growers, regulators, general public about "snake oils"*
- *Educate growers about resistance development in plant pathogen populations*
- *Educate growers and industry about disease identification*
- *Educate applicators on proper fungicide applications/techniques*
- *Educate growers on timing of rolling (e.g., don't do when wet)*

Insects

Insects that may cause economic damage in pulse crops include pea weevil, pea leaf weevil, aphids, grasshoppers, cutworms, and lygus bugs.

The pea weevil *(Bruchus pisorum*) is considered a serious pest of dry peas and is found throughout the entire pea production region. Pea weevils cause significant damage and economic loss nearly every year. Adult weevils overwinter in fencerow areas, in timbered areas adjacent to fields, and on roadside vegetation. Female weevils lay eggs within the pea pods during the early bloom stage, then the larvae remain within the peas, eating the pea seed from the inside and emerging after harvest (see also "Post-Harvest" section).

The pea leaf weevil (PLW, *Sitona lineata*) adult is a very serious pest in dry peas, causing economic loss in all production areas every year. Most of the damage occurs in the spring on peas in the seedling stage. Early adults feed on seedlings, scalloping leaf edges and damaging terminal buds. Severe foraging may cause heavy leaf damage, destruction of the terminal buds, and ultimate destruction of the plant.

Weather and soil conditions during the growing season have a strong influence on the damage caused by the PLW. Cool, wet spring weather slows dry pea development and extends the time that peas remain in the seedling stage, which makes them more susceptible to PLW. Some of the recently developed pea varieties are slower to mature, therefore at risk for greater PLW damage. Damage by the PLW can be localized or cover large areas. Severely infested dry pea fields may suffer up to 100% crop loss.

Aphids create serious pest problems in U.S. pulse crops, particularly lentils, but rarely damage Canadian crops. Pea aphids (*Acyrthosiphon pisum*) cause direct as well as indirect damage to plants. Direct damage caused by aphids feeding on plants is a depletion of plant vigor that can result in plant death. Pea aphids damage plants indirectly by vectoring viruses including pea enation mosaic. Infected plants become stunted and are non-productive. Aphids are most problematic in Region 1, where they move to pea and lentil fields in June, at about the time of bloom.

The cowpea aphid *(Aphis craccivora)*, though present in fields, is not considered a serious pest because it arrives in the field after the seeds are formed.

Grasshoppers can damage seedlings bordering ditches and roads, but they do not strongly prefer pulse crops. They chew through young seedlings even if they do not eat the plant. As few as two grasshoppers per square yard can cause serious yield losses in lentils. Grasshoppers are more likely to be a problem in the warmer, drier southwest region of Saskatchewan.

Cutworms occasionally cause damage to pulse crops. Cutworms overwinter as eggs or young larvae that feed on newly emerged shoots in the spring. The shoots are often cut off below the soil surface. Pulse crops can recover from cutworm damage if cool, moist growing conditions occur. Recovered plants are generally set back 4 to 7 days by the damage.

The lygus bug (*Lygus* spp.) is a major insect pest of lentils. Lygus has not been documented in dry peas. Hosts for these pests include weeds such as mustards and lambsquarters and crops such as alfalfa and clover. Lygus bugs pierce tender leaves, stems, buds, petioles, and developing seeds. They feed on lentils, producing depressed, chalk-colored lesions on the seed known as “chalky spot syndrome.”

Chickpea plants are covered with small hair-like glandular structures that secrete malic and oxalic acids which act as deterrents to insects. Insect problems on chickpeas are rare and insecticides are usually not needed, but occasional and serious problems occur with cutworms and grasshoppers. As with the other pulses, viral transmission by aphids can also be a problem in chickpea.

Cultural Practices

For pea weevil, scouting is employed before initiating control measures; the economic threshold is reached when more than two weevils per 25 sweeps are found. For pea aphid, no cultural controls are available, but scouting is employed before pesticides are applied. Aphid-resistant varieties would be used if available, but they are not currently available for commercial release. For grasshoppers, clean summer fallowing can be used to starve young insects as they emerge and trap strips (areas of green growth) are used to concentrate the grasshoppers before an insecticide is applied. For lygus bugs, there are no effective alternative controls or cultural practices in the United States. Disturbing habitat by disking near fencerows and mowing roadsides can potentially lower lygus bug numbers but these practices also injure overwintering populations of beneficial insects. As lygus are often controlled in the course of aphid control (as explained below under "Chemical Controls"), scouting is employed only when no aphid control is used; economic thresholds have been established for lygus bugs in lentils. When lentils are in bloom and podding has begun, sweep nets are used to determine presence and quantity of adult lygus bugs, though the low (6-inch tall) growth habit of lentils makes this method more difficult than in other crops. Any presence of lygus bugs just before or during bloom justifies treatment according to the lentil industry.

Biological Controls

Natural predators are usually not present in significant numbers to reduce pea weevil, pea leaf weevil, or aphid populations below economically damaging levels.

Chemical Controls

For pea weevil, once the economic threshold has been reached (see "Cultural Practices," above), insecticides are applied to prevent the females from laying eggs. Once eggs are laid on the pea pods, all treatments are ineffective. Phosmet (Imidan) is an essential insecticide for both pea weevil and pea leaf weevil control. Applications of phosmet (Imidan) are often combined with dimethoate (Cygon) for aphid control.

Controlling aphids with systemic aphicides is partially successful in reducing the field spread of viruses. Overwintering aphids feed on infected host crops and can spread virus to pulses before insecticides are applied for aphid control, but aphicides are useful in stopping the spread of secondary infection to pulses. Dimethoate (Cygon) is applied to 100% of Washington crops and 70-90% of Montana crops at the bloom stage. The higher label rate of 0.5 lb ai/a is necessary to reduce losses attributed to aphids to near zero percent. The lower label rate of 0.167 lb ai/a is not sufficient for sustained aphid control. Although other insecticides (esfenvalerate, malathion, disulfoton, carbaryl, methomyl, methyl parathion, and endosulfan) are registered for control of pea aphid, growers have tried them and none have provided a cost-effective control comparable to dimethoate.

The U.S.A. Dry Pea and Lentil Council and the Washington State Commission on Pesticide Registration have funded ongoing research to identify replacements for dimethoate. The products under trial are bifenthrin (Capture 2E); lambda-cyhalothrin (Warrior); cyfluthrin (Baythroid); a combination of cyfluthrin and imidacloprid (Legend); and thiamethoxam as either a seed treatment (Helix) or as a floral spray (Actara 25 WP). All of these products provide excellent pea aphid control.

The dimethoate application made for pea aphid control is typically sufficient for lygus bug control. Treatment for lygus bug usually takes place when treatment for pea aphid is made. This usually occurs at 50 percent bloom. The rate of dimethoate used for aphid control is adequate for lygus control.

Several compounds are being investigated for the control of lygus bugs in lentils, including thiamethoxam (Helix, Actara) and cyfluthrin + imidacloprid (Legend). These neonicotinoid insecticides have not been tested in lentils in the past.

Critical Needs for Management of Insects in U.S. and Canadian Pulse Crops from Emergence to Harvest:

Research

U.S. and Canada

- *Develop new insect management techniques (e.g., seed treatment, GMO, cultural control)*
- *Investigate possible biological control agents*
- *Investigate the use of softer chemicals*
- *Develop cost-effective grasshopper control tactics in chickpeas*
- *Develop thresholds for aphid and lygus bugs for pulses*
- *Develop cutworm controls particularly in chickpea, where there are no registrations*
- *Investigate effects of lygus damage to dry peas*
- *Develop cost-effective, suitable replacements for dimethoate*

Regulatory

U.S. and Canada

- *Expedite registrations for cutworm control in chickpea*

U.S.

- *Obtain registration of bifenthrin (Capture 2E) and other novel insecticides*
- *Maintain dimethoate as long as possible*

Canada

- *Obtain registration for grasshopper control product (pre-harvest and at harvest)*

Education

- *Educate growers on insect identification*
- *Educate growers on how to use economic thresholds*

Vertebrates and Other Non-Insect Pests

Rabbits and other foliage-eating vertebrates can pose problems in pulse crops, especially chickpeas.

Critical Needs for Management of Vertebrates and Other Non-Insect Pests in U.S. and Canadian Pulse Crops from Emergence to Harvest:

Research

U.S. and Canada

- *Develop pest management solution to rabbit problems especially in chickpeas*

Regulatory

- *None*

Education

- *None*

Harvest

Harvest of pulse crops typically takes place in August. The crop must dry out to a certain level before harvesting, but this drying usually occurs naturally, without the aid of chemical desiccants. Desiccant herbicides are important, however, in years of warm, wet springs and cool, wet summers that promote luxuriant plant growth. Under such conditions the crop will continue to flower and set pods and weeds will continue to grow as long as moisture is available. If growers must wait for natural dry down to occur under such high moisture conditions, they risk pod shattering, sprouting, seed coat slough, and seed bleaching. In years when weeds are less threatening, dry peas and lentils are mechanically swathed or direct combined. Timely harvest of dry peas and lentils is critical to avoid post-maturity disease.

Weeds

Weeds can be a significant impairment at the harvest stage. Weeds that remain luxuriant under available moisture will mechanically impair the harvest of the crop.

Diseases

Under wet weather conditions and in situations where crops were swathed prior to harvest, certain diseases may continue to spread in the swath. Among those are the ascochyta blights, botrytis gray mold, and sclerotinia white mold. Harvest of peas can also be hampered by powdery mildew infection. For further details see “Diseases” under the headings “Pre-Plant” and “Emergence to Harvest,” above.

Chemical Controls

Paraquat dichloride (Gramoxone Extra) and glyphosate (Roundup Ultra) are sometimes used as pre-harvest aids in dry pea and lentil production. Chemical desiccant use in dry peas and lentils varies on a yearly basis, depending upon the extent of the weed infestation and the natural dry down of the crop at maturity. While paraquat is also labeled as a harvest aid for chickpeas, using a desiccant can cause reduced seed sizes and pod drop, so it is generally avoided in this crop. Sometimes application of desiccants is limited to “green spots” within the field only.

Insects

Insects are not controlled at the harvest stage.

Critical Needs of U.S. and Canadian Pulse Crops at Harvest:

Research

U.S. and Canada

- *Develop better controls for perennial weeds (esp. field bindweed)*
- *Develop methods to stop growth of chickpeas in the fall (growth regulator or swathing)*
- *Develop additional determinate chickpeas*
- *Investigate cause of shatter problems in chickpea and peas*
- *Research safety of glyphosate (Roundup Ultra) application when using peas as forage*
- *Develop new chemistry for harvest aid in all pulse crops*
- *Develop taller lentil varieties*
- *Develop method of protecting chickpea pods from ascochyta*
- *Initiate breeding efforts for retention of quality traits (e.g., bleach resistance, height)*

U.S.

- *Develop larger database of effects on seed vigor when pre-harvest application of glyphosate (Roundup Ultra) are made*

Canada

- *Develop desiccants for chickpea*

Regulatory

U.S. and Canada

- *Harmonize registration of paraquat and diquat, glyphosate (Roundup Ultra) and glufosinate*
- *Expand glyphosate (Roundup Ultra) label to allow for use on peas intended as forage*
- *Reduce PHI on chlorothalonil (Bravo 500) (pod protectant)*

Canada

- *Expedite registration of diquat for chickpeas*

Education

U.S. and Canada

- *Educate growers about optimal timing of harvest aids to minimize shatter*
- *Educate growers about trash management in diseased fields*
- *Educate growers about market restrictions resulting from the use of certain products*

Post-Harvest

Seed moisture must be carefully watched during storage of pulses to prevent disease problems. Peas can safely be stored at 16 percent moisture. Chickpeas and lentils should be stored at 14 percent moisture. If moisture levels are too high, grain dryers can be used, but they must be used with extreme caution because they may cause mechanical and thermal damage to all pulse crops. Moisture is tested several times during first few weeks of storage to maintain proper levels and to prevent seed sweating. Aeration is used to cool and dry the seed and to avoid storage problems.

The pea weevil *(Bruchus pisorum)* often shows up as a problem during the post-harvest stage, but control must take place earlier (see “Emergence to Harvest” section). Typically, the eggs that were deposited during the early bloom period mature into larvae that emerge from the threshed peas after harvest. The larvae are not visible within the infested peas, but their feeding on the inside decreases the weight of the pea. Dockage for pea weevil varies from year to year and can be a major factor in overall yield reduction as the weevil-damaged peas are cleaned from the seed prior to processing.

Critical Needs of U.S. and Canadian Pulse Crops Post-Harvest:

Research

U.S. and Canada

- *Develop cost-effective fumigation controls (alternatives to phostoxin)*
- *Develop separation methods of pea-weevil-infested peas*
- *Develop weevil-resistant pea varieties*
- *Investigate late-stage management of kochia, Canada thistle, and Russian thistle in warm growing areas*

Regulatory

U.S. and Canada

- *Work to harmonize MRLs internationally*
- *Harmonize regulations in pulse crops grown for seed production*

U.S.

- *Work with APHIS to avoid fumigation of lentils (note Canadian policy)*
- *Work on phytosanitation issues in trans-Rocky Mountain shipment of crops grown for breeder seed*

Education

U.S. and Canada

- *Investigate "non-GMO" labeling as marketing tool*
- *Educate growers about moisture content to reduce damage for better storage*

For More Information

This document was designed to report the perspectives of the pulse growers of the United States and Canada. The pest management practices, critical needs, tables, and general conclusions presented here are the result of a cooperative effort by the Work Group listed at the front of the document. For additional information on the production of chickpeas, lentils, and dry peas in the United States and Candada, contact one of the following grower groups.

U.S.A. Dry Pea & Lentil Council
2780 W. Pullman Road
Moscow, ID 83843-4024
USA

Phone: 208-882-3023
Fax: 208-882-6406
http://www.pea-lentil.com

Pulse Canada
1212 - 220 Portage Avenue
Winnipeg, MB R3C 0A5
CANADA

Phone: 204-925-4455
Fax: 204-925-4454
http://www.pulsecanada.com

APPENDICES

A – Activity Tables

B – Efficacy Tables for Herbicides

C – Efficacy Tables for Fungicides

D – Efficacy Tables for Insecticides

E – Pesticide List

NOTES:

Efficacy tables are compilations of information concerning the efficacy of various compounds and practices for the crop and pest indicated. The tables are not indications of registration of specific products for specific pests. The tables compare the relative efficacy of available and potential products for each pest, thereby providing an indication of where research and registration efforts are needed.

Note that the United States employs the concept of "crop groupings," which widens the list of crops to which a product can legally be applied. Canada does not use this system. This can create confusion. For example, a U.S. label could be registered for dry beans, enabling its use on chickpeas, where this would not be the case in Canada.

Activity Tables for Chickpeas Grown in Regions 1 and 3

Cultural Activities

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Clean Seed	1,3	1,3	1,3	1,3								
Sample Soil			1	3	3				1,3	3		
Fertilize				1,3	1,3	3			3	3		
Irrigate					1	1, 3 (Alberta)			1, 3 (Alberta)			
Inoculate				1,3	1,3	3						
Plant			1	1	1,3	3						
Roll					1,3							
Test Petioles (N/A)												
Swath									1,3	1,3		
Mechanical Harvest								1	1,3	3		

Note: Information based on grower and pest control advisor experience.

Pest Management Activities and Crop Monitoring Profile

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Fumigate Fields									1	1	1	1
Treat Seed		1	1,3	1,3	3							
Apply Herbicide		1	1	1,3	1,3	1,3	3		3	3		
Cultivate Mechanically*			1	1,3	1,3	3			1			
Apply Fungicide				1	1	1,3	3	3				
Scout Pests					1	1,3	1,3	1,3	3			
Apply Insecticide					1	1,3						
Apply Spot Herbicide					1,3	1,3						
Rogue Weeds						1	1,3	3				
Apply Harvest Aid								1,3	1,3			

Note: Information based on grower and pest control advisor experience.
* For weed control and herbicide incorporation.

Activity Tables for Lentils Grown in Regions 1 and 3

Cultural Activities

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Clean Seed	1,3	1,3	1,3	1,3								
Sample Soil				3					1,3	1,3		
Fertilize				3	3				3			
Irrigate						3	3		3			
Inoculate				3	3							
Plant				1,3	1,3	1						
Roll				1,3	1,3	1						
Test Petioles (N/A)												
Swath						1	1,3	1,3				
Mechanical Harvest						1	1,3	1,3				

Note: Information based on grower and pest control advisor experience.

Pest Management Activities and Crop Monitoring Profile

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Fumigate Fields(N/A)												
Treat Seed		1,3	1,3	1,3								
Apply Herbicide		1	1	1,3	1,3	1,3						
Cultivate Mechanically*			1	1,3	1,3	1				3	3	
Scout Pests				1	1,3	1,3	1,3	1,3				
Apply Spot Herbicide				3	3	1,3	1,3	3	3			
Apply Fungicide					3	3	3					
Apply Insecticide					3	1,3	1,3	3				
Rogue Weeds						3	3					
Apply Harvest Aid							1	1,3	3			

Note: Information based on grower and pest control advisor experience.
* For weed control and herbicide incorporation.

Activity Tables for Dry Peas Grown in Regions 1, 2 and 3

Cultural Activities

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Clean Seed	1,2,3	1,2,3	1,2,3	1,2,3					1	1	1	1
Sample Soil			1	3	2				1	2,3		
Fertilize				3	2,3	2,3						
Irrigate*			1	1		3	3	3	1,3			
Inoculate			1	1,3	1,2,3	2,3						
Plant			1	1,3	1,2,3	2,3						
Roll			1	1	1,2,3	2,3						
Test Petioles†						3						
Swath								2,3	2,3			
Mechanical Harvest							1,3	1,2,3	1,2,3			

Note: Information based on grower and pest control advisor experience.
* Fields are pre-irrigated if necessary to increase soil moisture levels, then planted, rolled, and irrigated again.
† This activity is rare. Based on test, if nitrogen is needed, it is applied by fertigation.

Pest Management Activities and Crop Monitoring Profile

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Fumigate Fields (N/A)												
Treat Seed		1	1,2,3	1,2,3	2,3							
Apply Herbicide			1	1,3	1,2,3	2,3	2,3					
Cultivate Mechanically*			1	1,2,3	1,2,3				1,2			
Scout Pests			1	1	1,2,3	1,2,3	1,2,3	1,2,3				
Apply Insecticide			1	1	1,3	1,2,3	1,2					
Apply Fungicide			1	1	1	1,2,3	2,3					
Apply Spot Herbicide					2,3	1,2,3	1,2,3		2,3			
Rogue Weeds						2,3	2,3					
Apply Harvest Aid							1,2,3	1,2,3	2,3			

Note: Information based on grower and pest control advisor experience.
* For weed control and herbicide incorporation.

Efficacy Tables for Herbicides

This page covers preplant and preemergence applications and IPM/cultural strategies on pests A-L	PREPLANT/PRE-EMERGENCE MANAGEMENT TOOLS									IPM/CULTURAL				
	dimethenamid, dimethenamid-P (Frontier 6EC/ Outlook)	ethalfluralin (Sonalan)	glyphosate (Roundup Ultra)	imazethapyr (Pursuit)	s-metolachlor (Dual Magnum, Dual II Magnum)	metribuzin (Sencor*, Lexone)	pendimethalin (Prowl)	triallate (Far Go, Avardex BW)	trifluralin (Treflan)	Crop Rotation	Seedbed Prep	Clean Fields	Scouting	Preplant Cultivation
Registration (U=U.S., C=Canada, B=Both)	U	B	B	U	U	B	B	B	B	See below.				
(P)ea, (L)entil, (C)hickpea	LC	**	PLC	PLC	PLC	PLC	PLC	PLC	PLC	PLC				
barley, volunteer	P	P	E	G	E	P	P	N/A	F	Used by all growers on all three crops in both countries.				
barnyardgrass	E	E	E		E	N/A	G-E	N/A	E					
Canada thistle	N/A	N/A	P-G †	P	N/A	P	N/A	N/A	N/A					
chickweed, common	P	G-E	G	G-E	G	F	F-G	N/A	E-G					
chickweed, mouseear	P	P	P-G †	G	P	P	N/A	N/A	N/A					
clover	P		F-G	P	N/A	P	N/A	N/A	N/A					
cocklebur, common	P	P	G	G	P	F	P	N/A	N/A					
corn, volunteer	P	P-F	E §	G	P	N/A	P	N/A	P-F					
cornflower	P		G	F	P	P	P-F	N/A	N/A					
cow cockle	P	G-E	G-E	F	P	P	P-F	N/A	G-E					
crabgrass	G	N/A	E			N/A	G-E	N/A	G-E					
dandelion	P		G-E		P	P	N/A	N/A	N/A					
downy brome	P	F-G	E	F	G	P-F	P	G	F					
flixweed	P		F-G	E	P	F-G	P	N/A	N/A					
foxtail barley	P		G-E	P	N/A	N/A	P	N/A	N/A					
foxtail, green	G	G-E	E		E	G	E	N/A	E					
foxtail, yellow	G	G	E		G-F	N/A	E	N/A	E					
Gallium spp.	P	P	G	G	P	P-F	P	N/A	N/A					
gromwell, corn	P	N/A	G	F	P	P-F	P	N/A	N/A					
henbit	P	N/A	G	F	P	P-F	P-F	N/A	N/A					
horseweed/Canada fleabane	P	P	F-E	F	P	F-G	P	N/A	N/A					
Italian ryegrass	P	E	E	G	G-E	P-F	G-E	N/A	E					
jointed goatgrass	P	G	E	G	G-E	P	P-F	N/A	P-F					
knotweed, common	P	F-G	F	G	P-F	P-F	G	N/A	G-E					
kochia	P	F-G	P-F #	P-E ‡	P	F-G	P-F	N/A	P-F					
lambsquarter	F	G	G	G-E	F	F	G	N/A	P-G					

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control) and P = Poor (less than 60% control)

* When used post-emergence, Sencor causes greater crop injury and is less efficacious on target weeds.

** Sonalan is registered on dry peas in both countries, lentils only in Canada, and chickpeas only in the U.S.

*** These materials are currently in the registration pipeline for the countries indicated.

† Timing is critical for these chemicals against these weeds.

‡ Resistance is a concern for this chemical against these weeds.

§ Not Roundup-Ready. §§ Not Clearfield-type.

Roundup is effective on these weeds at the seedling stage, but not against late-emerging weeds.

With diuron post-harvest. N/A= not used against this weed pest

Efficacy Tables for Herbicides

This page covers preplant and preemergence applications and IPM/cultural strategies on pests M-Z	**PREPLANT/PRE-EMERGENCE MANAGEMENT TOOLS**									**IPM/CULTURAL**				
	dimethenamid, dimethenamid-P (Frontier 6EC/ Outlook)	**ethalfluralin (Sonalan)**	**glyphosate (Roundup Ultra)**	**imazethapyr (Pursuit)**	**s-metolachlor (Dual Magnum, Dual II Magnum)**	**metribuzin (Sencor*, Lexone)**	**pendimethalin (Prowl)**	**triallate (Far Go, Avardex BW)**	**trifluralin (Treflan)**	**Crop Rotation**	**Seedbed Prep**	**Clean Fields**	**Scouting**	**Preplant Cultivation**
Registration (U=U.S., C=Canada, B=Both)	**U**	**B**	**B**	**U**	**U**	**B**	**B**	**B**	**B**	See below.				
(P)ea, (L)entil, (C)hickpea	**LC**	******	**PLC**	**PLC**	**PLC**	**PLC**	**PLC**	**PLC**	**PLC**	**PLC**				
marshelder	**P**	**N/A**	**G**	**F**	**P**	**P-F**	**N/A**	**N/A**	**P**	**Used by all growers on all three crops in both countries.**				
mayweed chamomile (dogfennel)	**F**	**P**	**F-G**	**P**	**F**	**F**	**P**	**N/A**	**P**					
mustard, tall	**P**	**P-F**	**F-G**	**E**	**P**	**F-G**	**P**	**N/A**	**P**					
narrowleaf hawksbeard								**N/A**						
nightshade, black	**P**	**P**	**F-G**	**G-E**	**P**	**P**	**P**	**N/A**	**P**					
nightshade, hairy	**P**	**P-F**	**F-G**	**G-E**	**P**	**P**	**P**	**N/A**	**P**					
oat, volunteer	**P**	**G**	**E**	**G**	**P**	**P**	**P**	**E**	**F-G**					
oat, wild	**P**	**G**	**G-E**	**P**	**P**	**P**	**P**	**G-E**	**F-G**					
pennycress, field	**P**	**N/A**	**F-G**	**G-E**	**P**	**F-G**	**P**	**N/A**	**P**					
pigweed, prostrate	**G**	**G**	**F-G**	**G-E**	**G-E**	**G**	**G**	**N/A**	**G**					
pigweed, redroot	**G**	**G**	**F-G**	**G-E**	**G-E**	**G**	**G**	**N/A**	**G**					
prickly lettuce	**P**	**P**	**P-F**	**F**	**P-F**	**G-E**	**P-F**	**N/A**	**P**					
purslane, common		**E**	**P-G**	**G**			**G**	**N/A**	**G**					
quackgrass	**N/A**	**N/A**	**G-E †**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**					
ragweed, common	**P**	**P**	**F**		**P-F**	**P-G**	**P**	**N/A**	**P**					
redstem filaree		**G**	**G**	**G**	**F**	**P-F**	**F-G**	**N/A**	**F**					
Russian thistle	**P**	**P-F**	**P-F #**	**E ‡**	**F-G**	**P**	**P**	**N/A**	**G**					
shepherdspurse	**P**	**N/A**	**G-E**	**E**	**P-F**	**P-F**	**P**	**N/A**	**P**					
smartweed	**P**	**P**	**G-E**	**G**	**P-F**	**P-F**	**P**	**N/A**	**P**					
sowthistle	**P**	**N/A**	**G-E**	**F**	**P-F**	**F-G**	**P**	**N/A**	**P**					
vetch			**F-G**			**F**		**N/A**						
volunteer canola	**P**	**N/A**	**F-G §**	**E §§**	**P-F**	**P**	**N/A**	**N/A**	**P**					
wheat, volunteer	**P**	**F-G**	**E**	**F**	**P-F**	**N/A**	**P**	**N/A**	**F-G**					
wild buckwheat	**P**	**P-F**	**F-G**	**P**	**P-F**	**E**	**P**	**N/A**	**P**					
wild mustard	**P**	**N/A**	**F-G**	**E**	**P-F**	**P**	**P**	**N/A**	**P**					
wild radish	**P**	**N/A**	**G**	**G**	**P-F**	**P**	**P**	**N/A**	**P**					
wild sunflower	**P**	**N/A**	**F-G**	**P**	**N/A**	**F-G**	**P**	**N/A**	**P**					
yellow rocket	**P**	**N/A**	**F-G**	**E**	**P-F**	**P**	**P**	**N/A**	**P**					

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control) and P = Poor (less than 60% control)

* When used post-emergence, Sencor causes greater crop injury and is less efficacious on target weeds.

** Sonalan is registered on dry peas in both countries, lentils only in Canada, and chickpeas only in the U.S.

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† Timing is critical for these chemicals against these weeds.

‡ Resistance is a concern for this chemical against these weeds.

§ Not Roundup-Ready. §§ Not Clearfield-type.

Roundup is effective on these weeds at the seedling stage, but not against late-emerging weeds.

With diuron post-harvest. N/A= not used against this weed pest

Efficacy Tables for Herbicides

This page covers postemergence applications and potential new tools on pests A-L	POSTEMERGENCE MANAGEMENT TOOLS															NEW***	
	metribuzin (Sencor*, Lexone)	bentazon (Basagran)	clethodim (Select)	fenoxaprop + fluazifop (Fusion)	fluazifop (Venture)	imazethapyr (Pursuit)	imazethapyr + imazamox (Odyssey)	quizalofop P-ethyl (Assure II)	paraquat dichloride (Gramoxone Extra)	sethoxydim (Poast)	MCPA + MCPB (Tropotox Plus)	MCPB (Thistrol)	pronamide (Kerb) (winter peas - fall applied pre-emerge)	sodium salt of MCPA or PCPA amine (Chiptox)	imazamox/bentazon (Raptor/Basagran)	sulfentrazone (Spartan)	2,4-DB
Registration (U=U.S., C=Canada, B=Both)	B	B	C	C	C	C	C	B	U	B	C	U	U	B		B	U
(P)ea, (L)entil, (C)hickpea	PCL	P	PC	PL	PL	P	P	PCL		PCL	P	P		P	P	PC	L
barley, volunteer	P	N/A	E		E		G	E	G-E	E		N/A	E	N/A	E	P	N/A
barnyardgrass	P	N/A	E		G		G	E	G-E	E		N/A	E	N/A		F	N/A
Canada thistle	F	F-G†	N/A					N/A	F-G	N/A	P	F	N/A	P	F-G	N/A	F
chickweed, common	P-F	P	N/A			G	G	N/A	G-E	N/A		F	N/A	F	F	F	G
chickweed, mouseear	P	P	N/A				G	N/A	G-E	N/A		P	N/A	P	F	P	P
clover	P		N/A					N/A	F-G	N/A							
cocklebur, common	F-G	F-G	N/A					N/A	G-E	N/A		F	N/A	F	G	N/A	G
corn, volunteer	N/A	N/A	G		G			E	G-E	E		N/A	E	N/A	G	N/A	N/A
cornflower	P	P	N/A					N/A	G-E	N/A		P	N/A	F	G	F	F
cow cockle	P	P	N/A					N/A	G-E	N/A		P	N/A	F	G	F	F
crabgrass	N/A	N/A						G	F	E		N/A	E	N/A	E	P	N/A
dandelion	P	F-G	N/A					N/A	G-E	N/A		F-G	N/A	F	G	N/A	F
downy brome	P	N/A	P-F					G-E	F-G	G		N/A	E	N/A	G	N/A	N/A
flixweed	P	G	N/A					N/A	G-E	N/A		F	N/A	F	G	F	F
foxtail barley	P	N/A	P-F					G	F	G		N/A	N/A	N/A	F	N/A	N/A
foxtail, green	F	N/A	E		F	G	E	E	G-E	E		N/A	E	N/A	G	F	N/A
foxtail, yellow	P	N/A	E			E	E	E	G-E	F		N/A	E	N/A	G	F	N/A
Gallium spp.	P	P	N/A					N/A	F-G	N/A		P	N/A	P	G	P	F
gromwell, corn	P	P	N/A					N/A	G-E	N/A		F	N/A	F	G	F	F
henbit	P	P	N/A					N/A	G-E	N/A		F	N/A	F	G	F	F
horseweed/Canada fleabane	F	F-G	N-G			p		N/A	G-E	N/A		F	N/A	F	G	P	G
Italian ryegrass	P	N/A	G-E					E	F-G	E		N/A	G	N/A	G	N/A	N/A
jointed goatgrass	P	N/A	G-E					G-E	F-G	E		N/A	G	N/A	G	N/A	N/A
knotweed, common	P	P-F	N/A					N/A	G-E	N/A		F	N/A	F	G	F	F
kochia	F	P	N/A			F	G	N/A	G-E	N/A		P	N/A	P	G ‡	E	F
lambsquarter	P	F-G	N/A			G	G	N/A	G-E	N/A	G	G	N/A	G	G-F	G	G

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control) and P = Poor (less than 60% control)

* When used post-emergence, Sencor causes greater crop injury and is less efficacious on target weeds.

** Sonalan is registered on dry peas in both countries, lentils only in Canada, and chickpeas only in the U.S.

*** These materials are currently in the registration pipeline for the countries indicated.

† Timing is critical for these chemicals against these weeds.

‡ Resistance is a concern for this chemical against these weeds.

§ Not Roundup-Ready. §§ Not Clearfield-type.

Roundup is effective on these weeds at the seedling stage, but not against late-emerging weeds.

With diuron post-harvest. N/A= not used against this weed pest

This page covers postemergence applications and potential new tools on pests M-Z	**POSTEMERGENCE MANAGEMENT TOOLS**															**NEW*****	
	metribuzin (Sencor*, Lexone)	**bentazon (Basagran)**	**clethodim (Select)**	**fenoxaprop + fluazifop (Fusion)**	**fluazifop (Venture)**	**imazethapyr (Pursuit)**	**imazethapyr + imazamox (Odyssey)**	**quizalofop P-ethyl (Assure II)**	**paraquat dichloride (Gramoxone Extra)**	**sethoxydim (Poast)**	**MCPA + MCPB (Tropotox Plus)**	**MCPB (Thistrol)**	**pronamide (Kerb) (winter peas - fall applied pre-emerge)**	**sodium salt of MCPA or PCPA amine (Chiptox)**	**imazamox/bentazon (Raptor/Basagran)**	**sulfentrazone (Spartan)**	**2,4-DB**
Registration (U=U.S., C=Canada, B=Both)	B	B	C	C	C	C	C	B	U	B	C	U	U	B		B	U
(P)ea, (L)entil, (C)hickpea	PCL	P	PC	PL	PL	P	P	PCL		PCL	P	P		P	P	PC	L
marshelder	F-G	F-G	N/A					N/A	G	N/A		F	N/A	F	G	F	G
mayweed chamomile (dogfennel)	P	G	N/A					N/A	G-F	N/A		F	N/A	F	F-G	G-E	G
mustard, tall	F	P	N/A					N/A	G	N/A		F	N/A	F	G	F	F
narrowleaf hawksbeard			N/A					N/A	G	N/A		P	N/A				
nightshade, black	P	F	N/A					N/A	G	N/A		F	N/A	F	E	E	G
nightshade, hairy	P	F	N/A					N/A	G	N/A		F	N/A	F	E	E	G
oat, volunteer	P	N/A	G		G		G	E	G	G-E		N/A	E	N/A	E	N/A	N/A
oat, wild	P	N/A	G		G	F	G	G-E	G	G-E		N/A	E	N/A	E	N/A	N/A
pennycress, field	F	G	N/A			E	E	N/A	G	N/A		F	N/A	F	E	P	G
pigweed, prostrate	F	F	N/A			G	G	N/A	G-E	N/A		F	N/A	F	E	G-E	F
pigweed, redroot	F	F	N/A			G	G	N/A	G-E	N/A	G	F	N/A	F	F	G-E	F
prickly lettuce	F-G	F-G	N/A					N/A	F-G	N/A		F	N/A	F	F-G	P-F	F
purslane, common	P	P	N/A			G	G	N/A	F-G	N/A		P	N/A	P	F	N/A	P
quackgrass	P	N/A	P-F		F			P	N/A	P-F		N/A	N/A	N/A	N/A	N/A	N/A
ragweed, common	F-G	F-G	N/A					N/A	G	N/A		F	N/A	F	E	F	G
redstem filaree	F	P	N/A					N/A	G	N/A		G	N/A	F	E	F	G
Russian thistle	F	F-G	N/A					N/A	G-E ##	N/A		F	N/A	F	G ‡	E	P
shepherdspurse	F-G	P	N/A					N/A	G	N/A	G	F	N/A	F	E	P	F
smartweed	P	P	N/A			G		N/A	G	N/A		F	N/A	F	G	P	P
sowthistle	P-F	G	N/A					N/A	G	N/A	P	F	N/A	F	G	F	F
vetch			N/A					N/A	G	N/A		E	N/A				
volunteer canola	P	P	N/A					N/A	G-E	N/A		F	N/A	F	E §§	P	F
wheat, volunteer	P	N/A	E					E	G	E		N/A	E	N/A	G §§	P	N/A
wild buckwheat	G	P	N/A			G		N/A	G	N/A		F	N/A	F	F	F	P
wild mustard	P	P	N/A			E		N/A	G-E	N/A	G	F	N/A	F	E	P-F	F
wild radish	P	P	N/A			G		N/A	G	N/A		F	N/A	F	G	P	F
wild sunflower	P-F	P	N/A					N/A	G	N/A		G	N/A	G	G	P	F
yellow rocket	P	P	N/A					N/A	G	N/A		F	N/A	F	G	P	F

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control) and P = Poor (less than 60% control)

* When used post-emergence, Sencor causes greater crop injury and is less efficacious on target weeds.
** Sonalan is registered on dry peas in both countries, lentils only in Canada, and chickpeas only in the U.S.
*** These materials are currently in the registration pipeline for the countries indicated.
† Timing is critical for these chemicals against these weeds.
‡ Resistance is a concern for this chemical against these weeds.
§ Not Roundup-Ready. §§ Not Clearfield-type.
# Roundup is effective on these weeds at the seedling stage, but not against late-emerging weeds.
With diuron post-harvest. N/A= not used against this weed pest

Efficacy Table for Fungicides on Chickpeas

MANAGEMENT TOOL	Registration (U=U.S., C=Canada, B=Both)	Ascochyta blight (*Ascochyta rabiei*)	*Botrytis* spp.	*Fusarium* spp.	*Pythium* spp.	*Rhizoctonia spp.*	Comments
captan (Captan)	U	N	N	F	N	F	
pyraclostrobin (Headline)	U	G	?	N	N		
mefenoxam (Apron XL)	B	N	N	N	G	N	
azoxystrobin (Quadris)	U	G	?	N	N		
thiabendazole + carbathiin (Crown)	C	G	G			G	
chlorothalonil (Bravo 500)	C	F					
Section 24c Products							
chlorothalonil (Bravo) - WA	U	G	N	N	N		
thiabendazole (Mertect) - WA	U	G	?	F-G	N		
Section 18 Products							
fludioxonil (Maxim) - ND	U	?	N	G		G	
Pipeline Materials							
AMS 21619	U	G	?		N	?	
IPM and Cultural Control							
resistant varieties	B	Y	N	Y	N	N	
crop rotation	B	Y	N	Y	Y	Y	
increased distance between fields	B	Y	N				
disease-free seed (seed testing)	B	Y	Y	N	N	N	
scouting	B	Y	N				
row spacing	B	Y	Y				
seeding rate	B	Y	Y				

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

Y = yes   N = no; describes whether control measure is effective. Note that with the exception of resistant varieties, no non-chemical control measure will stand alone.

Efficacy Table for Fungicides on Lentils

MANAGEMENT TOOL	Registration (U=U.S., C=Canada, B=Both)	*Pythium* spp.	*Rhizoctonia* spp.	*Sclerotinia* spp.	*Fusarium* spp.	Ascochyta blight (*Ascochyta fabae* f. sp. *lentis*)	Anthracnose (*Colletotrichum truncatum)*	pea enation mosaic virus (PEMV)	bean (pea) leaf roll virus (BLRV)	*Botrytis* spp.	Comments
captan (Captan 400)	U	N	F	N	F	N	N	N	N	N	
carbathiin + thiram (Vitaflo 280)	C	N	G	N	G	F	N	N	N		
chlorothalonil (Bravo)	C	N		N	N	F	F	N	N	N	
fludioxonil (Maxim)	U		G	N	G	?	N	N	N	N	
mancozeb (Dithane)	C	N		N	N		P	N	N		
mefenoxam (Apron XL)	U	G			N	N	N	N	N	N	
thiabendazole + carbathiin (Crown)	C					G	N	N		G	
Section 18 Products											
thiabendazole (LSP flowable, Mertect LSP)(WA, MT)	U					G				?	
Pipeline Materials											
pyraclostrobin (Headline)	U	N		N	N	G	G	N	N	?	
azoxystrobin (Quadris)	U	N		F	N	G	G	N	N	?	
AMS 21619	U	N		G		G	?	N	N	?	
IPM and Cultural Control											
crop rotation	B	Y	Y	Y	Y	Y					
seedbed preparation	B	Y	Y	N	Y	Y					
clean seed	B	N	N	N	N	Y					
well drained soils	B	Y	Y	N	Y	N					
testing seed for Ascochyta blight	B					Y					
use of certified seed	B	N	N	N	N	N					
use of systemic insecticides to control aphids	B							Y	Y		

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

Y = yes   N = no; describes whether control measure is effective. Note that with the exception of resistant varieties, no non-chemical control measure will stand alone.

Efficacy Table for Fungicides on Dry Peas

MANAGEMENT TOOL	Registration (U=U.S., C=Canada, B=Both)	*Aphanomyces euteiches*	Foot rot (*Ascochyta pinodella*)	Ascochyta blight (*Ascochyta pisi, Mycosphaerella pinodes*)	Powdery mildew (*Ersiphe pisi*)	*Seedling blight (Fusarium)*	*Fusarium solani f. sp. pisi*	Fusarium wilt (*Fusarium oxysporum*)	Downy mildew (*Peronospora viciae*)	*Pythium* spp.	*Rhizoctonia* spp.	Sclerotinia stem rot (*Sclerotinia sclerotiorum*)	Bean (Pea) Leaf Roll Virus	Pea Enation Mosaic Virus	Comments
captan (Captan 400)	B	N	N	N	N	F	N	N	N	N	F	N	N	N	
fludioxonil (Maxim)	U	N	?	?		G	N	N			G	G	N	N	
mefenoxam (Apron XL)	U	N	N	N		N	N	N	G	G			N	N	
metalaxyl (Apron)	B	N	N	N		N	N	N	G	G			N	N	
PCNB	U	N	?					N		N	G	N	N	N	
thiram (Thiram 75WP)	B	N	?	?		F	N	N		N	F	F	N	N	
carbathiin + thiram (Vitaflo 280)	C	N	F	F		G	N	N		N	G	G	N	N	
chlorthalonil (Bravo)	C	N	N	F		N	N	N		N			N	N	
sulfur (Kumulus)	C	N	N	N	G	N	N	N		N			N	N	
mancozeb (Dithane)		N	N	P-F		N	N	N		N			N	N	
azoxystrobin (Quadris)		N	N	G			N	N		N			N	N	
pyraclostrobin (Headline)		N	N	G			N	N		N			N	N	
Section 24c Products															
thiabendazole (LSP flowable, Mertect LSP) (ND, MT)	U	N	G	G		F-G	N	N		N		N	N	N	
Biologicals and Others															
Some research (Idaho/Ottawa)	B														
Pipeline Materials															
AMS 21619	U				P-F		N	N		N			N	N	
myclobutanil (Nova)	U				G	N	N	N		N			N	N	
IPM and Cultural Control															
crop rotation	B	Y	Y	Y	*	Y		N	N	Y	Y	Y			* Early seeding date.
seedbed preparation	B	Y	Y	Y	N	Y		N	N	Y	Y	N			
clean seed	B	N	N	Y	N	N		N	N	N	N	N			
well drained soils	B	Y	Y	N	N	Y		N	N	Y	Y	N			
testing seed for Ascochyta blight	B			Y	N										
certified seed	B	N	N	N	N	N		N	N	N	N	N			
resistant cultivars	B	Y	Y	Y	Y	Y		Y	Y	N	N	N	Y	Y	
seed vigor	B	Y	Y	N	N	Y		N	N	Y	Y	N			
control aphids and leafhoppers	B												Y	Y	

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious.

Y = yes   N = no; describes whether control measure is effective. Note that with the exception of resistant varieties, no non-chemical control measure will stand alone.

Efficacy Table for Insecticides on Chickpeas

MANAGEMENT TOOL	Registration (U=U.S., C=Canada, B=Both)	Aphids	Alfalfa loopers	Armyworms	Redbacked cutworm	Pale western cutworm	Grasshoppers	Wireworms (*Limonius* spp.)	Comments
Insecticides									
esfenvalerate (Asana)	U		E	E			E		Costly; only used 2 out of every 8 years.
dimethoate (Cygon)	U		E	P			E		
Pipeline materials and possible biologicals									
imidacloprid (Provado)	U	E	?	?			?		
deltamethrin (Decis)	C								
permethrin (Ambush)	C								
IPM and Cultural Control									
scouting	B								
economic thresholds	C				P	P	P	P	No products and no thresholds in Canada.
habitat disturbance (e.g. cultivate/mow)									Not done by growers.
Candidates for New Solutions	B				Decis, Gaucho, Pounce, Helix, Matador	Decis, Gaucho, Pounce, Helix, Matador	Lorsban, Decis, Matador	Gaucho, Helix	
Priority Ranking	B				#1	#1	#3	#2	These pests are regional problems.
Comments	B							Need new control measure	

NOTE: Insects generally are not serious pests of chickpeas due to malic and oxalic acid secretion by these plants.

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious

(s) = secondary pest outbreaks (c) = tank mix

(r) = regional differences (rs) = resistance concerns

Efficacy Table for Insecticides on Lentils

MANAGEMENT TOOL	Registration (U=U.S., C=Canada, B=Both)	Pea aphid (*Acyrthosiphum pisum* (Harris))	Lygus bug (*Lygus hespeus* and *L. elisus*)	Wireworm (*Limonius* spp.)	Grasshopper	Redbacked cutworm	Pale western cutworm	Comments
Insecticides								
carbaryl (Sevin)	**U**	**N/A**	**P**	**N/A**				
chlorpyrifos (Lorsban)	**C**				**G**		**G**	
deltamethrin (Decis)	**C**				**G**	**G**	**G**	
dimethoate (Cygon)	**U**	**E**	**E**	**N/A**				Product of choice, others less efficacious and require tank mixing.
disulfoton (Di-Syston)	**U**	**N/A**	**?**	**N/A**				
endosulfan	**U**	**F**	**F-G**	**N/A**				
esvenvalerate (Asana)	**U**	**N/A**	**F-G**	**N/A**				Requires tank mixing; too expensive.
lindane	**U**	**N/A**	**N/A**	**E**				
malathion	**B**	**P(rs)**	**P(rs)**	**N/A**	**G**			
methomyl (Lannate)	**U**	**E**	**E**	**N/A**				Costly.
methyl parathion (Penncap-M)	**U**	**E**	**E**	**N/A**				Bee safety is an issue.
permethrin (Pounce)	**C**				**G**	**G**	**G**	
IPM and Cultural Control								
scouting	**B**	**G**	**G**	**P**	**G**	**F**	**F**	
economic thresholds	**B**				**G**	**G**	**G**	
habitat disturbance	**B**				**P**	**P**	**P**	e.g., cultivate/mow.
Pipeline Materials and Possible Biologicals								
bifenthrin (Capture 2E)	**U**	**E**	**E(rs)**	**N/A**				
lambda-cyhalothrin (Warrior)	**U**	**E**	**E**	**N/A**				
cyfluthrin (Baythroid)	**U**	**E**	**E**	**N/A**				
cyfluthrin + imidacloprid (Legend)	**U**	**E**	**E**	**N/A**				
thiamethoxam (Helix)	**U**	**E**	**E**	**?**				Seed treatment.
thiamethoxam (Actara 25 WP)	**U**	**E**	**E**	**N/A**				Foliar spray.
Highest Priority/ies for New Solutions				**X**				Gaucho or Helix are candidates.

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(s) = secondary pest outbreaks

(c) = tank mix

(r) = regional differences

(rs) = resistance concerns

(N/A) = not applicable

Efficacy Table for Insecticides on Dry Peas

MANAGEMENT TOOL, PART 1: INSECTICIDES (BIOCONTROL, IPM, AND PIPELINE MATERIALS ON NEXT PAGE)	Registration (U=U.S., C=Canada, B=Both)	Alfalfa loopers	Cowpea aphid (*Aphis craccivora*)	Grasshoppers	Leaf hoppers	Lepidoptera larvae	Lygus spp.	Pale western cutworm	Pea aphid (*Acyrthosiphon pisum* (Harris))	Pea Leaf Weevil (*Sitona lineata*)	Pea Weevil (*Bruchus pisorum*)	Redbacked cutworm	Wireworms (*Limonius* spp., *Hylema platura*)	Comments
Insecticides														
carbaryl (Sevin)	**U**		**N/A**			**G**			**N/A**		**N/A**		**N/A**	
chlorpyrifos (Lorsban)	**B**			**G**			**F-G**	**F**	**G**			**F**		
deltamethrin (Decis)	**C**			**G**			**G-E**							
dichloropropene (Telone II)	**U**		**N/A**			**N/A**			**N/A**	**N/A**	**N/A**		**?**	
diazinon/lindane seed trt	**C**													Not registered after 2004.
dimethoate (Cygon)	**B**		**E**			**E**			**E-G (r)**	**E**	**G**		**N/A**	1/2 lb ai on pea weevil.
disulfoton (Di-Syston)	**U**													Not used.
esfenvalerate (Asana)	**U**		**F**			**F**			**F**	**F**	**P**		**N/A**	Not cost efficient.
lindane	**U**		**N/A**			**N/A**			**N/A**	**N/A**	**N/A**			May be phased out.
malathion	**B**		**P(rs)**	**G**		**P(rs)**		**F**	**G-P(rs)**	**P(rs)**	**P(rs)**	**F**		Phytotoxic.
methomyl (Lannate)	**C**								**G**					
methoxychlor	**U**		**N/A**			**N/A**			**N/A**	**G**	**N/A**		**N/A**	Secondary pest outbreaks, not used alone.
parathion	**C**	**G**							**G**					
permethrin (Ambush)	**C**							**G**				**G**		
phosmet (Imidan)	**U**		**G**			**G**				**G**	**E(c)**		**N/A**	
pirimicarb (Pirimor)	**C**								**G**					
spinosad (Success)	**U**		**?**			**?**			**?**	**?**	**?**		**?**	
zeta-cypermethrin (Mustang)	**U**		**?**			**?**			**?**	**?**	**?**		**?**	

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(s) = secondary pest outbreaks
(rs) = resistance concerns
(c) = tank mix
(*) = parasitic wasp
(r) = regional differences

Efficacy Table for Insecticides on Dry Peas

MANAGEMENT TOOL, PART 2: BIOCONTROL, IPM, AND PIPELINE MATERIALS (REGISTERED CHEMICAL INSECTICIDES ON PREVIOUS PAGE)	Registration (U=U.S., C=Canada, B=Both)	Alfalfa loopers	Cowpea aphid (*Aphis craccivora*)	Grasshoppers	Leaf hoppers	Lepidoptera larvae	Lygus spp.	Pale western cutworm	Pea aphid (*Acyrthosiphon pisum* (Harris))	Pea Leaf Weevil (*Sitona lineata*)	Pea Weevil (*Bruchus pisorum*)	Redbacked cutworm	Wireworms (*Limonius* spp., *Hylema platura*)	Comments
Biological Insecticides														
Bacillus thuringiensis	**U**			**?**		**N/A**			**N/A**	**N/A**	**N/A**		**N/A**	
Pipeline materials and possible biologicals														
Aphidious ervii *	**U**								**?**					Research needed.
bifenthrin (Capture)	**B**		**E**			**E**			**E**	**E**	**E**		**N/A**	
lambda-cyhalothrin (Warrior)	**B**		**E**			**E**			**E**	**E**	**E**		**N/A**	
thiamethoxam (Actara 25WP)	**B**		**E**			**E**			**E**	**E**	**E**		**N/A**	
thiamethoxam (seed trtmt-Helix)	**B**								**P***		**P***		**E**	*Aphids generally appear at time of 7th node, also stage the seed treatment stops working.
IPM and Cultural Control														
crop rotation	**B**		**G**			**G**			**G**	**G**	**G**		**G**	
scouting	**B**		**E**	**G**	**G**	**E**	**P-G**	**G**	**P-E**	**E**	**E**	**G**	**E**	
economic thresholds	**B**		**E**	**G**		**E**		**F-G**	**P-E**		**E**	**F-G**	**E**	With virus could be updated.
habitat disturbance (e.g., cultivate/mow)	**B**			**P**				**P**				**P**		Not used in direct seeding systems.
Candidates for New Solutions	U	Parasitoids		Parasitoids	Parasitoids		Parasitoids	Parasitoids	Parasitoids, Actara		Actara	Parasitoids	Parasitoids, Gaucho, Helix	Lower Gaucho/Helix use rates need research in wireworms (current higher rates too costly and unnecessary for this pest)
highest priorities									**X**	**X**	**X**			

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-80% control), P=Poor (<70% control), ?=no data but suspected of being efficacious

(s) = secondary pest outbreaks
(c) = tank mix
(r) = regional differences
(rs) = resistance concerns
(*) = parasitic wasp

Pesticide List, Sorted by Trade Name

Trade Name	Ingredient	Trade Name	Ingredient	Trade Name	Ingredient
Achieve	tralkoxydim	Dual (II) Magnum	s-metolachlor	Nova	myclobutanil
Actara 25WP	thiamethoxam (floral spray)	DyVel DS	dicamba + 2,4-D + mecoprop	Odyssey	imazethapyr + imazamox
Affirm	tralkoxydim	Edge	ethalfluralin	Outlook	dimethenamid-P
Agrox	captan + diazinon + lindane	Embutox	2,4-DB	Paramount	quinclorac
Aim	carfentrazone-ethyl	Endosulfan	endosulfan	Paraquat	paraquat
Allegiance FL	metalaxyl	Estaprop	2,4-D + dichlorprop	Parathion	parathion
Ally	metsulfuron methyl	Everest	flucarbazone-sodium	PCNB	PCNB
Amber	triasulfuron	Express	tribenuron methyl	Peak	prosulfuron
Ambush	permethrin	Far-Go	triallate	Pirimor	pirimicarb
Amitrol	amitrole	Finesse	metsulfuron methyl + chlorsulfuron	Poast	sethoxydim
Apron FL	metalaxyl	Fortress	chlorethoxyfos	Poast FlaxMax	sethoxydim + clopyralid + MCPA
Apron XL	mefenoxam	Frontier 6EC	dimethenamid	Pounce	permethrin
Asana	esfenvalerate	Fusion	fluazifop-P-butyl + fenoxaprop	Prevail	tralkoxydim + 2,4-D triisopropanolamine + clopyralid
Assert	imazamethabenz-methyl	Gaucho	imidacloprid	Provado	imidacloprid
Assure II	quizalofop-P-ethyl	Glean	chlorsulfuron	Prowl	pendimethalin
Attain	fluroxypyr	Gramoxone Extra	paraquat dichloride	Puma	fenoxaprop-p
Avadex BW	triallate	Harmony Extra	thifensulfuron-methyl + tribenuron methyl	Pursuit	imazethapyr
Avenge	difenzoquat methyl sulfate	Harmony GT	thifensulfuron methyl	Quadris	azoxystrobin
Banvel	dimethylamine salt of dicamba	Headline	pyraclostrobin	Raptor	imazamox
Basagran	bentazon	Helix	thiamethoxam (seed treatment)	Refine Extra	thifensulfuron methyl + tribenuron methyl
Baythroid	cyfluthrin	Hoe-Grass II	diclofop-methyl + bromoxynil	Rival	trifluralin
Bonanza	trifluralin	Hoelon	diclofop-methyl	Roundup Ultra	glyphosate
Bravo 500	chlorothalonil	Horizon	clodinafop-propargyl	Select	clethodim
Bronate	bromoxynil octanoate + MCPA, 2-ethyl hexyl ester	Imidan	phosmet	Sencor	metribuzin
Buctril	octanoic acid ester of bromoxynil	Kerb	pronamide	Sevin	carbaryl
Caliber	2,4-DB	Kumulus DF	sulfur	Sonalan	ethalfluralin
Canvas	thifensulfuron methyl + tribenuron methyl + metsulfuron methyl	Lannate	methomyl	Spartan	sulfentrazone
Captan FL, Captan 400	captan	Laser DF	fenoxaprop-p-ethyl + 2,4-D + thifensulfuron	Starane	fluroxypyr 1-methylheptyl ester
Capture 2E	bifenthrin	Legend	cyfluthrin+ imidacloprid	Stinger	clopyralid, mono-ethanolamine salt
Champion Plus	fenoxaprop-p-ethyl + MCPA + 2,4-D + thifensulfuron	Lexone DF	metribuzin	Success	spinosad
Chiptox	MCPA, sodium salt	Liberty	glufosinate-ammonium	Target	MCPA + mecoprop + dicamba
Clarity	diglycolamine salt of dicamba	Lindane	lindane	Telone II	dichloropropene
Cobutox	2,4-DB	Lorsban	chlorpyrifos	Thistrol	MCPB
Compitox	MCPP	LSP	thiabendazole	Thiram 75WP	thiram
Crown	thiabendazole + carbathiin	Malathion	malathion	Tordon	picloram, potassium salt
Curtail	2,4-D triisopropa-nolamine + clopyralid	Matador	lambda-cyhalothrin	Tough	pyridate
Cygon	dimethoate	Maverick	sulfosulfuron	Treflan	trifluralin
Decis	deltamethrin	Maxim	fludioxonil	Triumph Plus	fenoxaprop-p-ethyl + thifensulfuron methyl + MCPA
Diquat	diquat	MCPA	MCPA	Tropotox Plus	MCPA + MCPB
Di-Syston	disulfoton	Mecoprop	MCCP	Turboprop	2,4-D + dichlorprop (as butoxyethanol or isooctyl ester)
Discover	clodinafop-propargyl	Mertect	thiabendazole	Venture	fluazifop-P-butyl
Dithane DG	mancozeb	Mustang	zeta-cypermethrin	Vitaflo-280	thiram/carbathiin
Diuron	diuron	Muster	ethametsulfuron	Warrior	lambda-cyhalothrin

Pesticide List, Sorted by Ingredient

Ingredient	Trade Name	Ingredient	Trade Name	Ingredient	Trade Name
2,4-D	(various)	diquat	Diquat	metsulfuron methyl + tribenuron methyl + thifensulfuron methyl	Canvas
2,4-D + dichlorprop	Estaprop, Turboprop	disulfoton	Di-Syston	myclobutanil	Nova
2,4-D + MCPA + fenoxaprop-p-ethyl + thifensulfuron	Champion Plus	diuron	Diuron	octanoic acid ester of bromoxynil	Buctril
2,4-D + mecoprop + dicamba	DyVel DS	endosulfan	Endosulfan	paraquat	Paraquat
2,4-D triisopropanolamine + clopyralid	Curtail	esfenvalerate	Asana	paraquat dichloride	Gramoxone Extra
2,4-D triisopropanolamine + clopyralid + tralkoxydim	Prevail	ethalfluralin	Edge, Sonalan	parathion	Parathion
2,4-DB	Caliber, Cobutox, Embutox	ethametsulfuron	Muster	PCNB	PCNB
amitrole	Amitrol	fenoxaprop-p	Puma	pendimethalin	Prowl
azoxystrobin	Quadris	fenoxaprop-p-ethyl + thifensulfuron methyl + MCPA	Laser DF, Triumph Plus	permethrin	Ambush, Pounce
bentazon	Basagran	fenoxaprop-p-ethyl + thifensulfuron + MCPA + 2,4-	Champion Plus	phosmet	Imidan
bifenthrin	Capture 2E	fluazifop-P-butyl	Venture	picloram, potassium salt	Tordon
bromoxynil octanoate + MCPA, 2-ethyl hexyl ester	Bronate	fluazifop-P-butyl + fenoxaprop	Fusion	pirimicarb	Pirimor
captan	Captan FL, Captan 400	flucarbazone-sodium	Everest	pronamide	Kerb
captan + diazinon + lindane	Agrox	fludioxonil	Maxim	prosulfuron	Peak
carbaryl	Sevin	fluroxypyr	Attain	pyraclostrobin	Headline
carbathiin + thiabendazole	Crown	fluroxypyr 1-methylheptyl ester	Starane	pyridate	Tough
carbathiin + thiram	Vitaflo-280	glufosinate-ammonium	Liberty	quinclorac	Paramount
carfentrazone-ethyl	Aim	glyphosate	Roundup Ultra	quizalofop-P-ethyl	Assure II
chlorethoxyfos	Fortress	imazamethabenz-methyl	Assert	sethoxydim	Poast
chlorothalonil	Bravo 500	imazamox	Raptor	sethoxydim + clopyralid + MCPA	Poast FlaxMax
chlorpyrifos	Lorsban	imazethapyr	Pursuit	s-metolachlor	Dual Magnum, Dual II Magnum
chlorsulfuron	Glean	imazethapyr + imazamox	Odyssey	spinosad	Success
chlorsulfuron + metsulfuron methyl	Finesse	imidacloprid	Gaucho, Provado	sulfentrazone	Spartan
clethodim	Select	imidacloprid+ cyfluthrin	Legend	sulfosulfuron	Maverick
clodinafop-propargyl	Discover, Horizon	lambda-cyhalothrin	Matador, Warrior	sulfur	Kumulus DF
clopyralid, mono-ethanolamine salt	Stinger	lindane	Lindane	thiabendazole	LSP, Mertect
clopyralid + 2,4-D triisopropanolamine	Curtail	lindane + captan + diazinon	Agrox	thiabendazole + carbathiin	Crown
clopyralid + 2,4-D triisopropanolamine + tralkoxydim	Prevail	malathion	Malathion	thiamethoxam (floral spray)	Actara 25WP
cyfluthrin	Baythroid	mancozeb	Dithane DG	thiamethoxam (seed treatment)	Helix
cyfluthrin+ imidacloprid	Legend	MCPA	MCPA	thifensulfuron methyl	Harmony GT
cypermethrin	Prevail	MCPA, sodium salt	Chiptox	thifensulfuron methyl + MCPA + fenoxaprop-p-ethyl	Laser DF, Triumph Plus
deltamethrin	Decis	MCPA + fenoxaprop-p-ethyl + thifensulfuron methyl	Laser DF, Triumph Plus	thifensulfuron + 2,4-D + MCPA + fenoxaprop-p-ethyl	Champion Plus
diazinon + lindane + captan	Agrox	MCPA + MCPB	Tropotox Plus	thifensulfuron methyl + tribenuron methyl + metsulfuron methyl	Canvas
dicamba + 2,4-D + mecoprop	DyVel DS	MCPA + mecoprop + dicamba	Target	thifensulfuron methyl + tribenuron methyl	Harmony Extra, Refine Extra
dichloropropene	Telone II	MCPA, 2-ethyl hexyl ester + bromoxynil octanoate	Bronate	thiram	Thiram 75WP
dichlorprop + 2,4-D	Estaprop, Turboprop	MCPB	Thistrol	thiram/carbathiin	Vitaflo-280
dichlorprop-D	(various)	MCPB + MCPA	Tropotox Plus	tralkoxydim	Achieve, Affirm
diclofop-methyl	Hoelon	MCPP	Compitox, Mecoprop	tralkoxydim+ clopyralid + 2,4-D triisopropanolamine	Prevail
diclofop-methyl + bromoxynil	Hoe-Grass II	mecoprop + dicamba + 2,4-D	DyVel DS	triallate	Avadex BW, Far-Go
difenzoquat methyl sulfate	Avenge	mefenoxam	Apron XL	triasulfuron	Amber
diglycolamine salt of dicamba	Clarity	metalaxyl	Allegiance FL, Apron FL	tribenuron methyl	Express
dimethenamid	Frontier 6EC	methomyl	Lannate	tribenuron methyl + thifensulfuron methyl	Harmony Extra, Refine Extra
dimethenamid-P	Outlook	metribuzin	Lexone DF, Sencor	tribenuron methyl + thifensulfuron methyl + metsulfuron methyl	Canvas
dimethoate	Cygon	metsulfuron methyl	Ally	trifluralin	Bonanza, Rival, Treflan
dimethylamine salt of dicamba	Banvel	metsulfuron methyl + chlorsulfuron	Finesse	zeta-cypermethrin	Mustang