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

Summary of a workshop held on
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Lead Author: Catherine H. Daniels
Editor: Sally O'Neal Coates

Contact Person: Catherine H. Daniels, Pesticide Coordinator
(253) 445-4611
cdaniels@wsu.edu

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Previous PMSP

In 2002, the pulse industries in both the United States and Canada expressed interest in positioning themselves to approach the North American Free Trade Agreement (NAFTA) Technical Working Group for the purpose of harmonizing crop protection materials and maximum residue levels (MRLs) and establishing a NAFTA label. A work group consisting of U.S. and Canadian growers, commodity groups, pest control advisors, regulators, and university specialists, along with representatives from the U.S. Department of Agriculture (USDA), the Western Region Pest Management Center (WRPMC), Agriculture and Agri-Food Canada (AAFC), and the Canadian Pest Management Regulatory Agency (PMRA) met for two days in Saskatoon, Saskatchewan, 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 research, regulatory, and education actions regarding pesticides. The result of this exercise was publication of the *Pest Management Strategic Plan for Pulse Crops (Chickpeas, Lentils, and Dry Peas) in the United States and Canada*, on June 20, 2003.

OUTCOMES

The 2002 PMSP listed registrations of sulfentrazone (Spartan) on chickpea and dry pea as Regulatory Priorities. EPA issued a federal label for Spartan in 2003.

The 2002 PMSP listed a registration for thiabendazole (LSP) on lentils as a Regulatory Priority. Section 18s for the Pacific Northwest, North Dakota, and Montana were available in the interim. South Dakota applied as well. Full registration is expected in 2007.

The 2002 PMSP listed harmonization of products, cropping zones, and MRLs as a Regulatory Priority. Representatives from the U.S. and Canadian pulse industries first met with the NAFTA Technical Working Group in September 2003. This group established protocols for harmonization of certain MRLs, formed a task force, and continue working toward the establishment of NAFTA labels.

The 2002 PMSP listed updating of the PMSP as an Education Priority. The 2006 update workshop and this resulting document focus on U.S. production and expand the participation of U.S. states to include California, South Dakota, and Nebraska.

The 2002 PMSP listed "tell EPA and registrants what pulse industry needs" as an Education Priority. Educational meetings took place at least annually in the following forms: trips to Washington D.C. to explain pest management issues, participation with Washington State Commission on Pesticide Registration specialty crop tour (attended by EPA personnel and registrants), membership in IR-4 Commodity Liaison Committee, and participation in NAFTA Technical Working Group (harmonization issues such as MRLs, labels and crop groupings/zones).

The 2002 PMSP listed obtaining a full label for 2,4-DB as a Regulatory Priority. This chemical was listed as an IR-4 Priority A project in 2006 and residue testing was completed at the end of the field season. A tolerance is expected to be issued by 2008.

At the 2002 PMSP workshop, participants listed obtaining a full label for pyraclostrobin (Headline) and azoxystrobin (Quadris) as Regulatory Priorities. Full registration of both products was announced in spring 2003 following the summer 2002 workshop. The speed at which registrations took place can be attributed to the PMSP process.

The 2002 PMSP listed developing pre- and post-emergence broadleaf herbicides as a Research Priority on lentils. Research on fall applications of ethalfluralin (Sonalan) to spring lentils resulted in 24c registrations in 2005 in North Dakota (ND-050019) and Montana (MT-06-0003).

The Pulse Crops Working Group for the Northern Plains, funded by the North Central IPM Center, was formed as a direct result of the 2002 Pulse PMSP.

The 2002 PMSP listed "educating growers on available resources" as an Education Priority. Regional pulse research review panels, made up of growers, are now beginning to coordinate funded research efforts across the country.

"Increase breeding efforts" was identified as a 2002 Research Priority on chickpeas, dry peas, and lentils. Resistance to Aphanomyces in peas is being developed and made available through ARS germplasm; resistance to Sclerotinia in peas and lentils is being identified and introduced into breeding lines; resistance to Ascochyta blight in chickpeas has been improved with the discovery of two pathogen types of the disease and subsequent release of varieties like 'Sierra' and 'Dylan' that contain resistance to both pathotypes.

Note that while registration of pyridate (Tough) was identified in 2002 as a Regulatory Priority, the manufacturer dropped the registration. The pulse industry remains ready to pursue a registration should another registrant buy the product.

For questions regarding critical needs addressed by subsequent regulatory actions in Canada, please consult the Pest Management Regulatory Agency (http://www.pmra-arla.gc.ca/) which is the counterpart to the U.S. Environmental Protection Agency.

Historical copies of the previous document, *Pest Management Strategic Plan for Pulse Crops (Chickpeas, Lentils, and Dry Peas) in the United States and Canada*, issued 6/20/2003, are kept at the Western IPM Center (formerly Western Region Pest Management Center) office. To request a copy contact Rick Melnicoe, Western IPM Center Director, at (530) 754-8378, or rsmelnicoe@ucdavis.edu.

Introduction

The Environmental Protection Agency (EPA) has completed the risk assessments required under the Food Quality Protection Act of 1996 (FQPA) and is continuing its pesticide re-registration process. However, with the advent of the FQPA and subsequent risk assessments, several pesticides were voluntarily cancelled or now have reduced or more restrictive label uses.

The Endangered Species Act (ESA) may also impact the availability or restrict the use of certain pesticides. The ESA requires that any federal agency, including EPA, taking an action that may affect threatened or endangered species must consult with either the National Oceanic and Atmospheric Administration (NOAA-Fisheries) or the U.S. Fish and Wildlife Service, as appropriate. Lawsuits have been filed against EPA alleging the agency failed to complete this consultation process.

One lawsuit resulted in the establishment of buffers for applications of certain pesticides around salmon-supporting waters in Washington, Oregon, and California. Threatened and endangered species other than salmon are located throughout pulse-growing regions and there are likely to be further requirements for the protection of these species, whether they are court-ordered or result from the consultation process.

Because buffers are not in general use, no one knows their impact on agro-ecosystems or the pest complex. Whether planted to crops, planted to vegetation that is habitat for beneficial insects, abandoned to weeds, or managed for other values, buffers have great potential to play a either a positive or negative role in the pest complex. If pest management needs in buffer zones are not addressed or understood, growers may simply resort to cultivation to keep these areas free of weeds. Improper cultivation practices may lead to increased sediment loads in streams.

The total effects of FQPA and ESA are yet to be determined. Clearly, however, new pest management strategies will be required in the industry. Growers and commodity groups recognize the importance of developing long-term strategies to address pest management needs. These strategies may include identifying critical pesticide uses; retaining critical uses; researching pest management methods with emphasis on economically viable solutions; and understanding the impacts of pesticide cumulative risk.

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.

Work Group

A work group consisting of growers, commodity groups, pest control advisors, regulators, USDA-ARS personnel, and university specialists met for one and one-half days in Spokane, Washington on February 27-28, 2006. The purpose of the meeting was to identify the needs of pulse growers with reference to possible research, education, and regulatory actions regarding pesticides. The result of this exercise was 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 work group 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 the transition to more sustainable pest management in pulse crops in the United States.

Work Group Members

CALIFORNIA
Mick Canevari, Weed Scientist, University of California

IDAHO
Jim Evans, Grower
Brian Silflow, Grower
Todd Scholz, USA Dry Pea and Lentil Council

MONTANA
Jack Riesselman, Plant Pathologist, Montana State University

NEBRASKA
David Baltensperger, Plant Breeder, then at University of Nebraska, now at Texas A&M University

NORTH DAKOTA
Brian Bergstrom, Grower
Stan Meyers, Grower
Carl Bradley, Plant Pathologist, North Dakota State University
Eric Eriksmoen, Weed Scientist, North Dakota State University
Eric Bartsch, North Dakota Dry Pea and Lentil Association

SOUTH DAKOTA
Henry Roghair, Grower
Thandiwe Nleya, Extension Agronomist, South Dakota State University
Brad Ruden, North-Central IPM Center Pulse Working Group

WASHINGTON
Ben Barstow, Grower
Roy Dube, Grower

Charlie Shrope, Processor, Spokane Seed Company
Joseph Yenish, Weed Scientist, Washington State University
Fred Muehlbauer, Plant Breeder USDA-ARS, now retired
Weidong Chen, Plant Pathologist, USDA-ARS
David Bragg, Entomologist, Washington State University

OBSERVERS/OTHERS PRESENT

Facilitator: Linda Herbst, Associate Director, Western Integrated Pest Management Center (WIPMC), University of California Davis
US EPA: Linda Murray
IR-4 Representative: Ronda Hirnyck
Washington State Department of Agriculture: Deborah Bahs
USDA Risk Management Agency: Heywood Baker, Dave Paul, Steve Junghans, and Mick Rice
Recorders: Catherine Daniels, Sally O'Neal Coates

Region Descriptions

For our discussion purposes, we have delineated four major pulse-growing regions in the United States. Regions 1, 3, and 4 were defined in the previous U.S./Canada PMSP. They retain most of the climatic and some of the geographic characteristics of the previous document, but Regions 3 and 4 in this document have additional U.S. area and do not include the Canadian portions from the previous document. Likewise, Region 2 is not discussed in this document. Region 5 is new to this document.

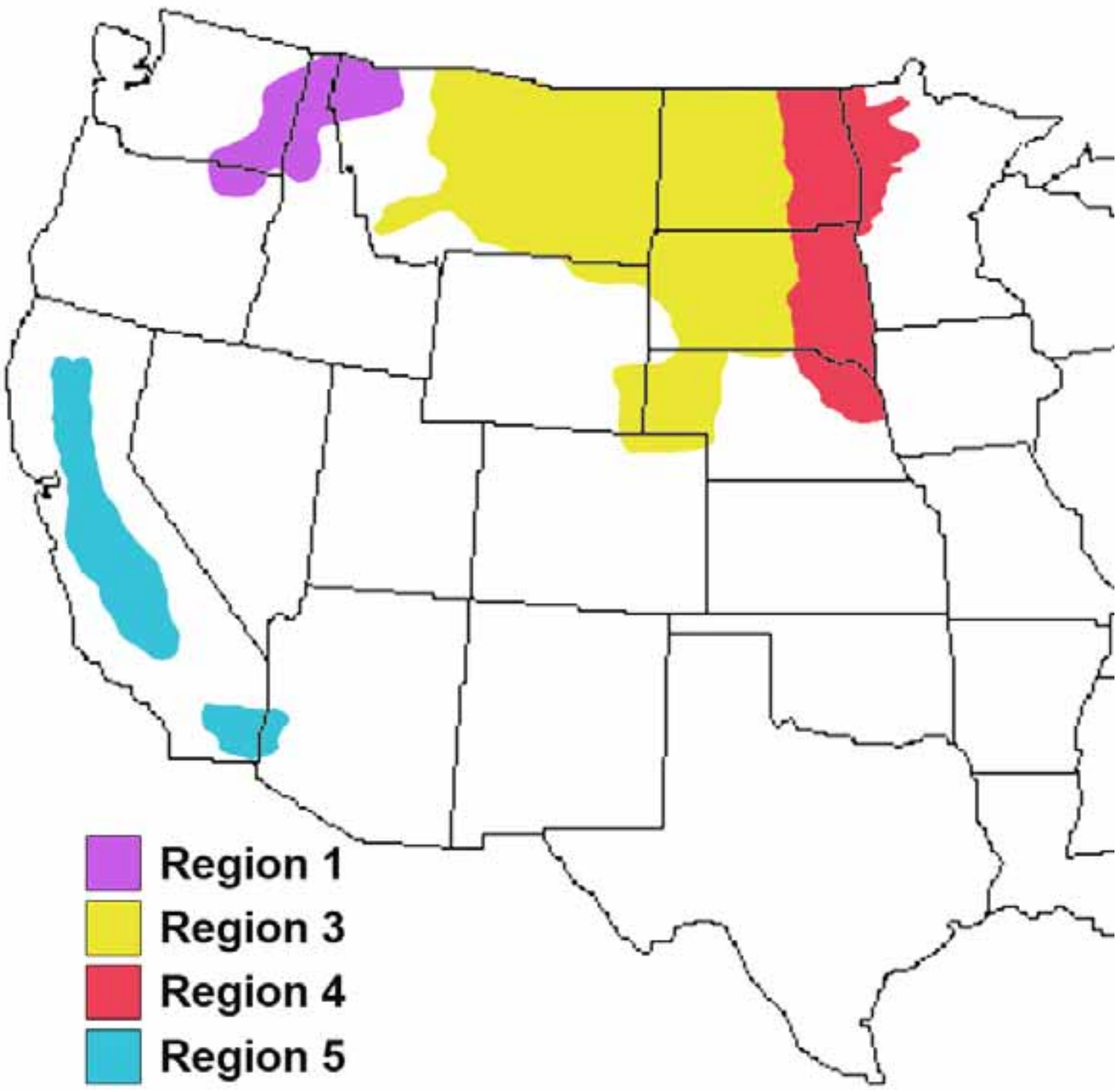
Region 1 is located in the Pacific Northwest states of Washington, Oregon, and Idaho and also includes extreme northwestern Montana. The majority of the pulse crop acreage within Region 1 is located in the Palouse region of eastern Washington and northwestern Idaho. The area predominantly has a Mediterranean climate distinguished as having warm dry summers and mild wet winters. Annual rainfall ranges from 16 to 25 inches with December and January typically being the months of heaviest rainfall. Soils are primarily loess types of loam and clay loam with pH in the range of 6 to 7 and organic matter in the 2.5 to 4.0 range. This region has the mildest climate among Regions 1-4.

Region 2, also known as the Canadian Parkland region, is located entirely in Canada and will not be discussed in this document.

Region 3 includes most of Montana, portions of northeastern and southeastern Wyoming, the western two-thirds of North Dakota and of South Dakota, northern and western Nebraska, and northeastern Colorado. These parts of the Plains States are characterized by an increasingly diverse cropping system that has added oilseed and pulse crops into a historical cereal crop and fallow rotation. The region is semiarid with rainfall ranging from 11 to 20 inches, most of which is received during the growing season. Annual precipitation increases as you move east through the region. Soil types within the region vary greatly. In general, the northern portion of Region 3 has deep clay soils characterized by their high moisture-holding capacity. In the more southern portions, the region has both shallow and deep soils ranging from sandy to clay. This region is prone to extreme fluctuations in temperatures with summer temperatures exceeding 100 ºF and winter temperatures dropping to -40 ºF. The extremes are more pronounced as you move north across the region.

Region 4 consists of the eastern one-third of the Dakotas, the northeastern corner of Nebraska, and the far western one-third of Minnesota. The average rainfall ranges from 14 to 22 inches, most of which is received during the growing season. The soil types vary from sandy loam in the western portion of the region to clay loam in the eastern portion. While the region produces a diverse array of crops, it only produces one of the pulse crops discussed in this document: dry peas. Rotation partners for dry beans in the region include corn, soybeans, canola, sunflowers, flax, small grains, sugarbeets, and potatoes.

Region 5 is the major US chickpea production area, which in general includes California's Sacramento Valley to the north, the San Joaquin Valley in the south-central part of the state and the Imperial Valley in the southern desert. Most plantings in this region occur in the fall and early winter months. Winter plantings rely on rain for moisture with one or two irrigations applied if needed in the spring. Soil types vary from sandy loams to clay/silt types.



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://www.ipmcenters.org/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 California, Colorado, Idaho, Montana, Nebraska, North Dakota, Oregon, South Dakota, and Washington.

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, which 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 (Region 3). There are five to six market classes of lentils grown in these regions, based on seed size, cotyledon color, and seed coat coloration.

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, and 6 to 20 mm long and 3 to 10 mm wide; they 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* spp. *arvense*)

Dry peas are a cool-season annual crop produced in Regions 1, 3, and 4. Also known as "field peas," 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.

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 ºF. 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.

Organic Production

Organic production of peas, lentils, or chickpeas for seed harvest begins with careful selection of fields for production based on presence of weeds, diseases, and insects. Pulses, especially peas, are also used in organic production systems as cover crops and forage crops as well as for grain and seed, but pest management requirements are generally less critical for cover and forage uses than with pulses grown for seed. The pest management problems of organically produced crops mirror those of conventional production. Efforts to develop disease- and insect-resistant varieties for conventional production have been, and will continue to be, key to the success of organic production. A non-GMO inoculant is applied when planting into soils that do not have a history of pea, lentil, or chickpea production.

DISEASE MANAGEMENT
Fields that do not have a history of recent annual pulse production are selected to reduce the incidence of pulse diseases. In addition, varieties that are the most resistant to the most prevalent diseases are selected wherever possible. Disease-free seed is critical to chickpea production and burial or destruction of pulse crop residue may be used as part of a disease reduction strategy.

INSECT MANAGEMENT
To avoid planting into high populations of wireworm, potential production fields may be bioassayed for wireworms before planting. Non-crop border habitat and/or refuge areas may be maintained to enhance populations of aphid natural enemies. Supplemental releases of aphid predators or parasitoids may be necessary in peas, and Lygus predators may be employed in lentils. In peas, planting is sometimes delayed until after conventional crops in the area have emerged to reduce pea leaf weevil infestation. To combat pea seed weevil, border and/or refuge areas may be seeded to a trap crop of Austrian Winter Pea or another purple-flowered pea variety a week or two before seeding the organic pea crop.

WEED MANAGEMENT
Since available pulse varieties are generally poor competitors, fields with historically high populations of weeds are avoided. Unless planted in rows, fields are seeded and then cross-seeded at a combined rate of 180-200 lbs. per acre. Planting is often delayed to allow additional clean cultivation before planting. Post-emergence harrowing, especially with a rotary hoe, may also be used. Rotary hoeing may be done more than once and can be quite effective in managing small weed seedlings during the first three weeks following planting. Depending on variety and growth habit, harrowing is only practical for a short time after crop emergence because it can damage the crop.

Critical Needs Summary

The following list summarizes those needs determined by the work group to be the most critical to pulse crop pest management. Overall top priorities are listed first, followed by the top priorities for each of the three pulse crops under examination.

RESEARCH

- Research and/or develop broadleaf weed controls, especially post-emergent, targeting kochia, nightshades, Mayweed chamomile, prickly lettuce, and sowthistle.
- Develop varieties with resistance to diseases (Ascochyta in chickpea, pea enation virus in dry pea, root rots in all pulses) and insects.
- Continuing and additional research on biology of pathogens and insects.
- Further investigate transgenic breeding for pest management.
- Research disease management through crop rotation and resistant varieties.
- Find an alternative to systemic insecticide dimethoate.
- Develop an effective aphid management program and associated tools (e.g. seed treatments that persist in systemic manner).
- Improve crop quality and breeding for competitiveness and desirable characteristics such as bleach resistance.

REGULATORY

- Register 2,4-DB, linuron, clethodim (Select), prometryn, thiabendazole (LSP seed treatment), prothioconazole (Proline), and other triazole fungicides.
- Standardize crop groupings and crop zones.
- Ensure that pesticide labels for legume crops list winter legumes on the label.
- Work with registrants and EPA to expedite pesticide registrations and label reviews/decisions (i.e., PRIA)
- Defend the dimethoate registration at the 0.5 lb rate. *(As of 1/07, this use was retained on lentils for control of Lygus and aphid.)*
- Work with NRCS to establish crop residue requirements for CSP and other Farm Bill programs.

EDUCATION

- Communicate economic benefits of growing and consuming pulse crops (system approach/crop rotation, moisture, organic matter, and disease management).
- Develop an electronic one-stop website for pulses. Site would optimally include: forecasting, weather, markets, pesticides, plant-back issues, global information, seeding, production practices, MRLs, and resistance ratings.
- Offer programs on pesticide modes of action and resistance management.
- Educate funding sources on need for long-term research projects.
- Develop and offer programs on disease and insect management.
- Educate consumers on pulse crops and acceptance of GMOs.

Crop-Specific Critical Needs

CHICKPEAS

Research

- Research whether current plant-back restrictions are strictly necessary, especially in the case of chickpeas (e.g., planting after simazine).
- Research atrazine and simazine efficacy and applicability in chickpeas.
- Research imazamox and prometryn in chickpeas.
- Develop biological-based control for Pythium (damping off) in chickpea.
- Investigate new chemistries for weed control such as Harmony GT, Express, Spartan, linuron, diruon, prometryn.
- Develop methods to stop growth of chickpeas in the fall (e.g., growth regulator, swathing).
- Develop cost-effective grasshopper control tactics in chickpeas.
- Develop cutworm controls in chickpea, where there are no registrations.
- Develop solution to rabbit problems.
- Develop additional determinate chickpea varieties.
- Develop method of protecting chickpea pods from Ascochyta.

Regulatory

- Add Ascochyta to the chickpea section of the azoxystrobin (Dynasty) label.
- Pursue California registrations for pesticides registered in other chickpea-growing regions.
- Expedite registrations for cutworm control in chickpea.

Education

- California chickpea growers may need to secure their fields.

LENTILS

Research

- Are currently mandated rotational timings (pea-pea 2 yr, lentil-lentil 2-yr) necessary? (Crop insurance issue.)
- Develop taller lentil varieties.
- Continue varietal research for higher crop residue (greater biomass) in lentils (to reduce erosion).
- Research elimination of chalky spot on peas and lentils, including investigation/development of resistant varieties.

Regulatory

- Pursue 2,4-DB registration for lentils.

Education

- None listed

DRY PEAS

Research

- Develop a more competitive upright pea plant.
- Investigate effects of Lygus damage to dry peas.
- Develop methods to separate pea-weevil-infested peas from those not infested.
- Develop weevil-resistant pea varieties.
- Research elimination of chalky spot on peas and lentils, including investigation/development of resistant varieties.

Regulatory

- None listed.

Education

- None listed.

Pest Management Strategic Plan Foundation

The remainder of this document, after a brief discussion of Integrated Pest Management and Rotational Pest Management, is an analysis of pest pressures during the various stages of pulse production from pre-plant through shipping and storage. Each crop production period is subdivided by pest (e.g., weed, disease, insect) and, for each pest, key control measures and their alternatives (current and potential) are discussed. Differences between production regions throughout the United States are discussed where appropriate. All three pulse crops are discussed in each section, with differences and similarities in pest control noted. Critical needs in the areas of research, regulation, and education are identified at the end of each section. In order to orient the reader to the timing of various activities and crop stages, tables indicating production, crop monitoring, and pest management activities are provided as Appendix A.

INTEGRATED PEST MANAGEMENT

Integrated pest management begins with understanding the pest situation in the region and field, and matching those conditions with pulse varieties that are best suited for managing those stresses. A major emphasis is now underway to develop varieties with multiple pest resistance traits that, when incorporated into adapted germplasm, will simplify pest management. A long-term effort is needed by the industry to develop improved pest tolerance in our adapted pulse crop germplasm. An example is the reduction in fungicide required to manage Ascochyta blight with more tolerant varieties.

ROTATIONAL PEST MANAGEMENT

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 (or even three) in advance to allow for proper site preparation, rotation partner selection, and plant-back considerations.

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 **(following page)**

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. Partially taken from Plantback Restrictions for Herbicides used in the Dryland Wheat Production Areas of the Pacific Northwest. *Hanson, B. D., R. A. Rauch, and D. C. Thill. PNW 571. Univ. of Idaho.*

HERBICIDE	CHICKPEAS	LENTILS	DRY PEAS
2,4-D*	30 days to 3 mo.	30 days to 3 mo.	30 days to 3 mo.
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 + 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 + tribenuron methyl + metsulfuron methyl)	10-34 months	10-34 months	10-15 months
Curtail** (2,4-D triisopropanolamine + clopyralid)	10.5-18 months	18 months	18 months
Discover (clodinafop-propargyl)	30 days	30 days	30 days
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 mo.	30 days to 3 mo.	0 days to 3 mo.
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 + 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)	10 months	10 months	10 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

‡ Safe plant-back interval varies in years with low moisture and use of high label rate, in overlap areas, or at field edges (turnings).
* 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 a crop that can 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.

WEEDS

Perennial weed control begins 1-3 years in advance of the pulse crop with herbicide applications or tillage operations. 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. The crop rotation scheme, which may include chemical fallow, can help 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.

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

Critical Needs for Management of Weeds in Pulse Crops in Rotational Pesticide Management:

Research

- Research whether current plant-back restrictions are strictly necessary, especially in the case of chickpeas (e.g., planting after simazine).
- Research whether currently mandated rotational timings (e.g., pea-pea 2 years, lentil-lentil 2 years) are necessary (crop insurance issue).

Regulatory

- Adjust currently mandated rotational timings (replant intervals) to reflect new research as data becomes available.

Education

- Educate growers on plant-back restrictions and related issues.

DISEASES/INSECTS

Growers do not consider rotation partners with respect to diseases or insects, although there is some interest in researching whether rotation strategies impact diseases.

Critical Needs for Management of Diseases in Pulse Crops in Rotational Pesticide Management:

Research

- Research disease implications of rotation partners.

Regulatory

- None listed.

Education

- Educate growers on disease implications of rotation partners as research-based information becomes available.

NEMATODES

At this time, there is no recognized economic problem with nematodes on pulse crops. Pea cyst nematode is becoming a problem on processing peas in Skagit County (northwestern Washington State), which could indicate a potential concern in the future. Nematodes have the potential to limit pulse production in some regions (e.g., the South), but as they are not currently recognized as an economic pest, they have not been a research priority so far.

Critical Needs for Management of Nematodes in Pulse Crops in Rotational Pesticide Management:

Research

- Find alternatives to methyl bromide for fumigation
- Research interactions of nematodes with root rots.
- Survey presence, population densities, and impacts of nematodes.
- Investigate cost-effective management techniques including breeding for resistance once nematode presence and impacts are determined.

Regulatory

- When a methyl bromide alternative is determined, expedite registration.

Education

- Communicate information as it becomes available.

Pre-plant

For purposes of this document, "Pre-plant" is defined as the 4- to 6-month period preceding planting during which the chemical tool must be labeled for pulse crops.

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. 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, and 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. Such approaches are not without problems, however, as weeds continue to emerge throughout the growing season. Indeed, warm-season annual weeds may be favored by delayed seeding. Delayed seeding also diminishes yield potential and quality, so this disadvantage must be weighed against any weed control advantage.

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 by reduced-tillage methods, the previous crop is very important. Volunteer canola and tame mustard are 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 still further.

Few herbicides are registered for managing weeds, especially broadleaf weeds, in pulse crops. Perennial broadleaf weeds like field bindweed and Canada thistle cannot successfully be controlled during the fall before seeding pulses, so these weeds 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.

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
The most problematic weed pests in each region are listed below.

Region 1 (semiarid Pacific Northwest)
Perennials: Canada thistle, field bindweed, quackgrass
Annual Grasses: wild oat, Italian ryegrass, downy brome, jointed goatgrass, volunteer cereals
Annual Broadleaves: 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, annual sowthistle

Region 2 (Canadian Parkland)
This region is located entirely in Canada and is not discussed in this document.

Region 3 (semiarid Northern Plains)
Perennials: Canada thistle, field bindweed, quackgrass, perennial sowthistle, dandelions, foxtail barley (perennial grass)
Annual Grasses: wild oat, downy brome, Japanese brome, Italian ryegrass, jointed goatgrass, Persian darnel, volunteer cereals, foxtail (green, yellow and giant)
Annual Broadleaves: annual sowthistle, 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, vetch, roundleaf mallow, common mallow, Canada fleabane/horseweed, wild buckwheat, cow cockle, wild sunflower, volunteer flax

Region 4 (subhumid Northern Plains)
Perennials: Canada thistle, field bindweed, quackgrass, perennial sow thistle, dandelions, foxtail barley (perennial grass), Persian darnel
Annual Grasses: wild oat, downy brome, volunteer cereals, foxtail (green, yellow, and giant)
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 soybeans, volunteer legumes, narrowleaf hawksbeard, vetch, wild buckwheat, cow cockle

Region 5 (warm California valleys)
Perennials: field bindweed, yellow and purple nutsedge, johnsongrass
Annual Grasses: volunteer cereals, barnyardgrass, crabgrass, annual grasses
Annual Broadleaves: brassicas (mustard, wild radish), prickly lettuce, nightshades, common lambsquarters, pigweeds, annual sowthistle, cocklebur, jimson weed

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 predominant) 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, type, placement) 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 affect 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 the development of resistance. Herbicide-resistant crops complicate weed control. For example, the potential release of additional glyphosate-resistant crop varieties (e.g., Roundup Ready) 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 additional 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, dandelion, or prickly lettuce and is not effective on annual weeds not yet emerged.
- Ethalfluralin (Sonalan) is registered, but herbicide carryover onto winter wheat that is planted within 6 months is unacceptable. Also ineffective on many weeds including mustards.
- 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 is weak on wild oat, dog fennel, and prickly lettuce; efficacy varies on lambsquarters. Many weeds are resistant.

- Pendimethalin (Prowl), when applied in combination with imazethapyr (Pursuit), widens the spectrum of broadleaf control, but does not control wild oat or other grasses. Prowl is seldom applied by itself.
- Triallate (Far-Go) uses a different mode of action than the other herbicides. It controls only wild oats and it must be incorporated twice. Ground and surface water detections have raised concerns about this chemical.
- Sulfentrazone (Spartan) is now labeled but is not completely effective on some of Region 1's weed spectrum.
- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop's pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.
- Dimethenamid (Outlook) is registered for annual grasses and broadleaves, but provides less than total control on dog fennel (a.k.a. mayweed chamomile).
- 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.
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.

Region 3:

- Imazethapyr (Pursuit) is widely used in Region 3, but there are concerns regarding crop injury potential in soils with low organic matter content and low moisture. Many weeds are resistant to Pursuit.
- Sulfentrazone (Spartan) is a key herbicide for kochia, Russian thistle, pigweed, and wild buckwheat, but control is erratic for wild buckwheat. Requires rainfall for activation.
- Dimethenamid (Outlook) is not registered on chickpea in this region.
- Dinitroamines (DNAs) such as pendimethalin (Prowl), trifluralin (Treflan), and ethalfluralin (Sonalan) 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. Sonalan and Treflan labels require two incorporations, therefore these chemicals don't fit into low-till or no-till systems. Prowl can be incorporated with water (but rain does not always occur timely) or mechanically. In the northern part of Region 3 Prowl can be applied in the fall, increasing the likelihood of winter moisture aiding incorporation.
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, dandelion, or prickly lettuce and is not effective on any annual weed not yet emerged.
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.

Region 4:

- Chickpeas are not grown in Region 4.

Region 5:

- Glyphosate (Roundup Ultra) has little utility in a tillage system where weeds are mechanically removed before planting. It's not effective on all weed species, particularly on burning nettle, malva, bur clover and glyphosate-resistant weeds such as Italian ryegrass, horseweed, and flaxleaf fleabane.
- Paraquat (Gramoxone) is effective on small weeds only. Not effective on perennial weeds. As a restricted use pesticide, there are worker safety problems.
- Dinitroamines (DNAs) such as pendimethalin (Prowl), trifluralin (Treflan), and ethalfluralin (Sonalan) are used for control of a broad range of summer weeds and grasses. They are less effective on many winter annuals, when most of the plantings occur. They must be mechanically incorporated, which adds another field operation before planting.

Lentils

Region 1:

- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat or prickly lettuce and is not effective on any annual weed not yet emerged. In effect, nothing is available for buckwheat control.
- Pendimethalin (Prowl), when applied in combination with imazethapyr (Pursuit), widens the spectrum of broadleaf control, but does not control wild oat or other grasses. Prowl is seldom applied by itself. While pendimethalin is registered for buckwheat control, carryover of herbicide is unacceptable when 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 it may cause crop damage. Effective control is lost at reduced rates. Imazethapyr is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters. Many weeds are resistant to it.
- Triallate (Far-Go) uses a different mode of action than the other herbicides. It controls only wild oats and it must be incorporated twice.
- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop’s pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not used very often because of plant-back restrictions on winter wheat.
- Dimethenamid (Outlook) is registered for annual grasses and broadleaves, but provides less than total control on dog fennel (a.k.a. mayweed chamomile).
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.

Region 3:

- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat or prickly lettuce and is not effective

on any annual weed not yet emerged. High rates of glyphosate are applied for foxtail barley and dandelion control.
- Imazethapyr (Pursuit) is not used in Montana, due to crop injury potential on soils with low organic matter content and low moisture. Pursuit is used in North Dakota.
- North Dakota has a 24c registration for ethalfluralin (Sonalan), particularly as a fall application preceding spring planting.
- S-metolachlor (Dual Magnum) was recently registered for North Dakota; information on use is not yet available.
- DNAs such as pendimethalin (Prowl), trifluralin (Treflan), and ethalfluralin (Sonalan) 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. Sonalan and Treflan labels require two incorporations, therefore these options don’t fit into low-till or no-till systems. Pendimethalin (Prowl) can be incorporated with water (but rain does not always occur timely) or mechanically.
- Dimethenamid (Outlook) is registered for annual grasses and broadleaves, but provides less than total control on dog fennel (a.k.a. mayweed chamomile).
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.
- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop’s pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.

Regions 4 & 5:
- Lentils are not grown in these regions.

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, dandelion, or prickly lettuce and is not effective on any annual weed not yet emerged.
- Ethalfluralin (Sonalan) is registered, but herbicide carryover onto winter wheat that is planted within 6 months is unacceptable for spring-seeded peas. (Not a problem for fall-seeded winter peas.) Also ineffective on many weeds including mustards.
- 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 is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters and many weeds are resistant to it.
- Pendimethalin (Prowl), when applied in combination with imazethapyr (Pursuit), widens the spectrum of broadleaf control, but does not control wild oat or other grasses. Pendimethalin is seldom applied by itself.
- Triallate (Far-Go, Avadex BW), which uses a mode of action different from other herbicides, controls only wild oats and must be incorporated twice.

- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop's pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not applied often because of plant-back restrictions on winter wheat. This is not a problem for fall-seeded winter peas.
- Trifluralin (Treflan) is labeled, but seldom used due to carryover and the need for incorporation. This is not a problem for fall-seeded winter peas.
- Pronamide (Kerb) is labeled for pre-plant on winter peas but is not used because of excessive cost and carryover potential. Not labeled for food peas.

Region 3:

- 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 is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters, and many weeds are resistant to it.
- 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. Preliminary crop damage reports necessitate use rate changes.
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, dandelion, or prickly lettuce and is not effective on any annual weed not yet emerged.
- Ethalfluralin (Edge) is registered, but herbicide carryover onto winter wheat that is planted within 6 months is unacceptable for spring-seeded peas. (Not a problem for fall-seeded winter peas.) Also ineffective on many weeds including mustards.
- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop's pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.
- Trifluralin (Treflan) is labeled, but seldom used due to carryover and the need for incorporation. This is not a problem for fall-seeded winter peas.
- DNAs such as pendimethalin (Prowl), trifluralin (Treflan), and ethalfluralin (Edge) are used for a narrow spectrum of broadleaf weeds and some grassy weeds. They do not sufficiently control mustards or wild buckwheat. Edge and Treflan labels require two incorporations, therefore these options don't fit into low-till or no-till systems. Pendimethalin (Prowl) can be incorporated with water (rain does not always occur timely) or mechanically. In the northern part of Region 3 it can be applied in the fall, increasing the likelihood of winter moisture aiding incorporation.
- Paraquat (Gramoxone) is registered but not used due to excessive cost.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not applied often because of plant-back restrictions on winter wheat. This is not a problem for fall-seeded winter peas.
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.

Region 4:

- 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 is weak on wild oat, dog fennel, prickly lettuce, and common lambsquarters, and any weeds are resistant to it.
- 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. Crop injury is not as much of a problem in Region 4.
- Glyphosate (Roundup Ultra) is applied pre-plant fall or spring for annual weeds, though it is not very effective on buckwheat, dandelion, or prickly lettuce and is not effective on any annual weed not yet emerged.
- Ethalfluralin (Edge) is registered, but herbicide carryover onto winter wheat that is planted within 6 months is unacceptable for spring-seeded peas. (Not a problem for fall-seeded winter peas.) Also ineffective on many weeds including mustards.
- Metribuzin (Sencor) is used for control of annual broadleaf weeds, particularly during the crop's pre-emergent and post-emergent stage. Its pre-plant use is limited due to crop injury (particularly if applied in areas with heavy moisture, i.e., 1/2 inch of rain within 48 hrs. of application) and lack of efficacy.
- Trifluralin (Treflan) is labeled, but seldom used due to carryover and the need for incorporation. This is not a problem for fall-seeded winter peas.
- DNAs such as pendimethalin (Prowl), trifluralin (Treflan), and ethalfluralin (Sonalan) are used for a narrow spectrum of broadleaf weeds and some grassy weeds. They do not sufficiently control mustards, nightshades or wild buckwheat. Sonalan and Treflan labels require two incorporations, therefore these options don't fit into low-till or no-till systems. Pendimethalin (Prowl) can be incorporated with water (rain does not always occur timely) or mechanically.
- Like pendimethalin (Prowl), sulfentrazone (Spartan) must be incorporated with water, and rain does not always occur timely.
- Paraquat (Gramoxone) is registered but not used due to excessive cost.
- S-metolachlor (Dual Magnum, Dual II Magnum) is not applied often because of plant-back restrictions on winter wheat. This is not a problem for fall-seeded winter peas.
- Carfentrazone (Aim) is used pre-plant. It is a non-residual, foliar-contact product but has demonstrated poor weed control.

Region 5:

- Dry peas are not grown in this region.

Critical Needs for Management of Weeds in Pulse Crops Pre-plant:

Research

- Develop improved management options at the pre-plant or pre-emergence stage for buckwheat, kochia, Russian thistle, prickly lettuce, vetch, Roundup Ready canola, wild sunflower, annual sowthistle, and dog fennel.
- Investigate herbicides with new modes of action.

- Improve perennial weed management options.
- Develop strategies for application, including methods, timing, and rates, to allow existing compounds' use on pulses and rotational crops (toward more success stories like Sonalan).
- Investigate glyphosate tank-mixes for broader-spectrum weed control (e.g., prickly lettuce, wild buckwheat, annual sowthistle, marestail/horseweed, fleabane, Roundup Ready canola).
- Investigate carryover of fall-applied phenoxy compounds on pulses.
- Investigate interaction of chemical controls with soil organic matter/pH.
- Improve winter annual broadleaf control and crop safety in winter peas, lentils, and chickpeas.
- Develop metribuzin-tolerant and sulfentrazone-tolerant varieties.
- Research atrazine and simazine efficacy and applicability in chickpeas.
- Research thifensulfuron, tribenuron, linuron/diuron, and imazethapyr + glyphosate in pulses.
- Research imazamox and prometryn in chickpeas.

Regulatory
- Ensure that the legume crop group includes winter legumes.
- Work with pesticide registrants and IR-4 to include residue sampling for both seed and foliage on dry pea. (This will allow the pesticide to be used on all dry pea crops, such as winter biotypes, for both food and feed purposes.)
- Continue to improve/clarify/harmonize crop groupings.
- Re-evaluate the validity of current field trial regions (zone mapping).
- Evaluate the possibility of relief from certain data requirements for minor use situations and label extensions/additions.
- Register dimethenamid-P, linuron/diuron, and metribuzin across all regions and pulse crops.
- Register imazamox and prometryn in chickpeas.

Education
- Develop and update 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 familiarity with crops and issues.
- Work with registrants on defining and meeting educational needs.

DISEASES

Cultural Practices
The major diseases present at this stage are seed-borne Ascochyta, damping off, and white mold (Sclerotinia). 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 to allow residues to decompose and pathogen numbers to fall off.

Residue management practices such as straw chopping, burial, or burning may be considered. Agronomic practices such as seed testing, field selection, seedbed preparation, seed handling, date of planting, row spacing, *Rhizobium* inoculation for nitrogen fixation, and weed management are part of disease control at the pre-plant stage. In California, some growers practice deep plowing to bury *Sclerotinia* pathogens. Cultivar selection is discussed in the following crop stage, "Planting."

Chemical Controls
A variety of chemical seed treatments are available for partial control of some disease pathogens. Seed treatments are discussed in the following crop stage, "Planting."

Critical Needs for Management of Diseases in Pulse Crops Pre-plant:

Research

- Investigate residue-associated disease management.
- Investigate effect of soil fertility on disease.
- Research alternatives to field burning.

Regulatory

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

Education

- Educate growers about residue/stubble management alternatives.
- Educate growers on disease management.

INSECTS

Insects are not typically a pre-plant problem in pulse crops. Field selection and crop rotations can affect insect pressure. In areas where grasshoppers are a problem, the previous year's egg count may play a role in field selection. If wireworms are present, growers may use trap crops such as carrots to determine wireworm presence, particularly in organic systems. At the pre-plant stage, growers can use forecasting models to plan for insect control in later crop stages. No insecticides are applied at pre-plant.

Critical Needs for Management of Insects in Pulse Crops Pre-plant:

Research

- Research potential problem of alternative hosts adjacent to pulse fields.
- Pursue novel and alternate means of control through prevention.

Regulatory

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

Education

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

Planting

Variety selection at planting is critical to the success of the crop. It is imperative that varieties with general adaptation to the region be identified as well as varieties that best counter the stresses in a given field. End uses and markets need to be considered as some varieties fit very specific market niches. As new varieties are developed, testing programs to assure their performance in each region will be needed.

Lentils, dry peas, and desi chickpeas are cool-season crops that can be seeded early into cool soils (40℉); kabuli chickpeas require warmer soils (46-50℉). 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 systems 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 plowed or chiseled in the fall is cultivated for weed control and herbicide incorporation, then harrowed and rolled. (Pulse beds are also rolled after planting, which is discussed at the beginning of the "Pre-emergence" section, following.) 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 shallower depth than systems utilizing 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). Low-till/no-till systems limit the ability to incorporate pesticides, which is required with some herbicides. Also, the untilled residues remaining on the soil surface from the previous crop may tie up residual herbicides, rendering them ineffective.

On the balance, direct seeding and low-till/no-till methods have distinct advantages. Mulch from surface residue changes surface ecology. The 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

Cultural Practices

Choice of seed and planting methodology are key components in weed management at planting. Pulse growers use clean, weed-free seed to avoid introducing new weed species into fields, including 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. Growers in some states utilize certified seed, which is weed-free and also results in greater vigor. Selection of herbicide resistant varieties, when available, is useful in later weed management.

Optimal seeding rate, timing, spacing, and depth also help ensure a vigorous crop and impact the crop’s ability to compete with weeds. The use of drills with an appropriate amount of soil disturbance also aids in managing weeds.

Weeds that emerge with or before the crop have a greater impact on the crop than those that emerge later. Some growers manipulate the timing of their pulse crop seeding to take advantage of known weed emergence and enhance the crop’s ability to compete. Early seeding may allow the crop to get a head start before the weeds emerge. This is especially true with respect to 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. However, delayed seeding, when combined with tillage prior to seeding or crop emergence, may be employed to eliminate early and more competitive weeds and to activate soil-incorporated herbicides. However, delayed seeding is risky as it generally reduces quality and yield. Non-selective pre-emergent herbicides (discussed in the previous section, “Pre-plant”) create the same advantage as pre-emergent tillage by clearing the field as the small crop seedlings emerge.

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 Pulse Crops at Planting:

Research

- Develop a more competitive upright pea plant.
- Research optimum planting density for competitiveness against weeds.

Regulatory

- None.

Education

- Educate growers on importance of using weed-free seed.
- Educate growers on importance of proper planting depth.

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, yield, and quality. Seed infected shortly after planting may fail to emerge or may 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 genera are involved in causing seed and root rots: *Rhizoctonia*, *Fusarium*, and *Pythium*. 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.

The pathogen causing Ascochyta blight can overwinter 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 white mold/Sclerotinia (*Sclerotinia sclerotiorum*), Botrytis gray mold (*Botrytis cinerea*), and anthracnose of lentil (*Colletotrichum truncatum*). In some areas soil-borne *Aphanomyces euteiches* causes serious root rot in pea.

Cultural Practices

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 *Rhizoctonia, Botrytis, Sclerotinia,* or *Pythium* species. Pea cultivars vary in their tolerance to Ascochyta blight. Some chickpea and lentil cultivars with partial resistance to Ascochyta blight are available and breeding efforts are underway to identify improved resistance.

Chemical Controls

Fungicidal seed treatments are the key chemical strategy employed at planting.

Captan (Captan 400) has historically been applied as a seed treatment, usually in combination with mefenoxam (Apron XL), but its use is declining due to potential harmful effects on the *Rhizobia* inoculum. Captan is, however, a very effective broad-spectrum fungicide, especially for the control of seedling rot.

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 mefenoxam controls *Pythium.* Metalaxyl (Allegiance) is also used for *Pythium* control.

Currently, no fungicide seed treatments are registered for use against *Aphanomyces euteiches.*

Some states have received Section 18 exemptions for thiabendazole (LSP, Mertect) against seed-borne *Ascochyta* in lentils, while 24c special local needs registrations allow this chemical's use in some states on chickpeas.

Critical Needs for Management of Diseases in Pulse Crops at Planting:

Research

- Conduct additional research on in-furrow and 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 interactions.
- Develop cost-effective quantitative PCR (polymerase chain reaction) method for pathogen detection in seed and/or soil.
- Breed resistant varieties.

Regulatory

- Obtain a Section 3 label for thiabendazole (LSP, Mertect).
- Add Ascochyta to the chickpea section of the azoxystrobin (Dynasty) label.
- Resolve potential regulatory issues with some fungicide seed treatments.

Education

- Educate growers on specific seed treatments and application techniques.
- Continue to educate growers about agronomic practices.
- Educate growers on the need for disease-free seed with high purity, germination, and vigor.
- Develop a web-based resource and/or other tools for educating growers on disease-resistant varieties.
- Educate research funding sources about the importance of supporting plant breeding.

INSECTS

Wireworm 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.

Critical Needs for Management of Insects in Pulse Crops at Planting:

Research
- Develop alternative controls for wireworm.
- Develop longer-term systemic seed control for later insects.
- Continue development of resistant varieties.
- Develop forecast models for various insects including pea leaf weevil and lepidopteran larvae.

Regulatory
- None.

Education
- Continue to communicate the importance of seed treatment for wireworm control.

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

Cultural Practices
Rotary hoeing, harrowing, and rolling are mechanical controls useful in weed management. No-till cultivation practices also serve as a method of weed control.

Chemical Controls
Metribuzin (Sencor) is applied pre-emergence 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. Use of metribuzin requires deeper seeding

and growers must watch soil pH and organic matter levels or risk crop injury. California recommends half of the listed label rates. Sencor is not labeled on chickpeas.

Oxyfluorfen (Goal) is used in Region 5 for chickpeas. It has a different mode of action and controls a wider weed spectrum than metribuzin. Glyphosate (Roundup Ultra) is registered for in-crop use. Paraquat (Gramoxone) is labeled for in-crop use in California. Preliminary damage reports for dry pea necessitate use rate changes in sulfentrazone (Spartan) for dry peas and chickpeas. Imazethapyr (Pursuit) is little used in Region 3 and not used in Region 5 because of plant-back restrictions. It is not often used in Region 1 at this timing because it needs deeper incorporation and is therefore too hard to incorporate at this stage. Dimethenamid-P (Outlook) is registered on lentils and chickpeas (except in California), but is rarely used alone. It is usually tank-mixed with imazethapyr for chamomile control. Carfentrazone (Aim) is used for burn-down if the grower did not apply glyphosate or if the glyphosate produced insufficient results. This use, however, is not registered in California. S-metolachlor (Dual, Dual Magnum) is not used in Region 1 due to carryover issues nor in Region 5 because it is not effective on that region's weed spectrum. It is, however, used in Regions 3 and 4.

Critical Needs for Management of Weeds in Pulse Crops at Pre-emergence:

Research

- Determine optimal timing and method of application of weed control products.
- Investigate pre-emergent annual broadleaf control in pulse crops.
- Investigate mechanical methods of weed control.
- Investigate mechanical methods of herbicide incorporation.
- Research expansion of herbicide use during the fall for winter legumes.
- Investigate new chemistries for weed control such as Harmony GT and Express, Spartan, linuron, diuron, prometryn (chickpeas).

Regulatory

- Expand Pursuit label, harmonization for all 3 crops.
- Work with registrants to maintain active ingredient registrations and new registrations.
- Modify the interpretation of a minor crop as stated by FIFRA.
- Continue to utilize and fund IR-4 to promote minor crop registrations.
- Expedite the registration of linuron for all pulse crops.
- Pursue California registrations for pesticides registered in other chickpea-growing regions.

Education

- Educate registrants on our registration priorities; work with them to maintain and develop new 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 Pulse Crops at Pre-emergence:

Research
- Breed for resistance to damping off and root rot (Pythium, Rhizoctonia, and Aphanomyces).
- Investigate the effect of rolling on root rot and seedling diseases.

Regulatory
- Explore the possibility of hymexazol (Tachigaren) for Aphanomyces control.

Education
- None.

INSECTS

Insects are not controlled at the pre-emergent stage.

VERTEBRATES

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 gophers and pheasants (birds and rodents) dig for sub-surface seeds. Lindane, once used against vertebrates, is no longer sold, but some remains in use, restricted to stocks on hand.

Critical Needs for Management of Vertebrates and Other Non-Insect Pests in Pulse Crops at Pre-emergence:

Research
- Investigate biological (non-chemical) seed treatment with repellent properties.
- Investigate avicides and bird repellents.
- Investigate the use of zinc phosphide-treated grain pellets.
- Investigate the relationship of crop residue levels and populations of vertebrate pests.

Regulatory
- Expedite registration zinc phosphide (IR-4) for pulse crops.

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. Some lentils and dry peas are swathed or desiccated prior to harvest due to uneven maturity or weed infestation, an operation that also requires specialized combine attachments. Chickpeas may be swathed prior to harvest, but this is less common.

Fields are inspected prior to harvest for variety characteristics and certifiability of seed. The California Crop Improvement Association (CCIA), the official seed-certifying agency in California, works closely as a partner with the chickpea seed industry to assist in the production and certification of high-quality seed. This seed certification service is a voluntary quality assurance program for the maintenance and increase of agronomic and vegetable crop seed. The certification process encompasses identity of planted seed, field inspections, and the monitoring of seed from the field, through the conditioning plant, and into the bag. Seed samples are taken and are examined in a seed laboratory to meet minimum germination and purity standards especially with respect to weeds and diseases. Seed, passing certification, is labeled with a “certified” tag.

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 further 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, Canada thistle, kochia, prickly lettuce, false chamomile, wild sunflower, sow thistle, wild buckwheat, 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.

While mechanical weed control is generally considered impractical from mid to late season due to the crops’ low and prostrate growth habit, some producers, especially those producing organic pulses, cultivate for weed control in the early part of this crop stage. This is more common in chickpeas. In-crop row cultivation is detrimental due to erosion concerns, especially in Region 1.

Chemical Controls

Quizalofop (Assure II) is applied post-emergence to all 3 pulse crops to control grass weeds such as wild oats, volunteer cereals, and other annual and perennial grasses. Some biotypes are resistant to this product and it not registered in California. Growers not using a pre-plant application of triallate (Far-Go, Avadex BW) will apply quizalofop post-emergence.

Sethoxydim (Poast) is another grass herbicide. Like quizalofop, sethoxydim has the advantage of controlling weeds on an "as needed" basis. Neither quizalofop nor sethoxydim exhibit much phytotoxicity, but resistant biotypes exist for both products. While sethoxydim is effective on annual grass weeds, it is too expensive for dryland producers and it has limited tank-mix options.

Metribuzin (Lexone DF, Sencor) is a systemic post-emergent herbicide used in dry pea and lentil production. It kills susceptible plants (e.g., mayweed chamomile, common lambsquarters) by inhibiting photosynthesis. It is not labeled for post-emergent use in chickpeas. It is applied early post-emergence 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 weed root zone. However, excessive rainfall can move metribuzin deeper into the soil where it can cause injury to lentil plants that are sown less than two inches deep or in soil that has low levels of organic matter. Plant injury and effectiveness against weeds are very dependent on weather conditions. Another limitation is that metribuzin cannot be tank-mixed with other herbicides.

Bentazon (Basagran) or bentazon + sethoxydim (Result) provides excellent control of pineapple weed and mayweed in dry peas. Bentazon 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. Bentazon requires good leaf contact for best results and must be applied during active weed growth, when temperatures are above 72°F and below 85°F.

Imazamox (Raptor) is registered for dry peas only and is used for annual grass control and some broadleaf weed control. Crop injury in peas can occur and it needs to be tank mixed with bentazon to be effective. It is extremely temperature sensitive especially over 85°F, and there may be carryover issues to subsequent canola crops.

Imazethapyr (Pursuit) has a label but it is not effective, therefore use is extremely limited. Its four-month plant-back restriction is another limiting factor when used late in the season.

MCPA sodium salt is used for annual broadleaf weed control in dry peas. It may cause crop injury, it can't be tank-mixed with grass herbicides, and it shows an extremely narrow weed-control spectrum. MCPB (Thistrol) is used as a spot treatment for perennial thistle suppression but it is only labeled on dry peas. California growers can't use phenoxy herbicides due to the proximity of their fields to grape production and the potential for drift.

Clethodim (Select, Prism) is only registered for chickpeas. It is used for annual grass control and, in California, for perennial grass control as well. There might be resistance issues with this product.

Glyphosate (Roundup Ultra) is used as a spot treatment or with a wiper bar, in-crop, for perennial weed suppression. It is also used as a harvest aid. Resistance has been reported in the Willamette Valley.

Paraquat (Gramoxone) is used as a harvest aid. There are worker safety issues associated with this material, which requires 20 GPA water for application.

Carfentrazone (Aim) is registered nationally as a desiccant but is relatively new so there is not much data.

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. An international survey of herbicide-resistant weeds is available on-line at http://www.weedscience.org . This database tracks hundreds of resistant biotypes and thousands of regions and can be searched geographically, by weed, or by herbicide mode of action.

Critical Needs for Management of Weeds in Pulses from Emergence to Harvest:

Research

- 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 overall 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 sowthistle control in dry peas, lentils and chickpeas.
- Investigate Canada thistle control in pulses.
- Research and develop herbicide-resistant cultivars.
- Research the timing of dessicants and the effect on crop quality.
- Evaluate the effectiveness and economics of diquat as a harvest aid.
- Evaluate the effectiveness and economics of glufosinate as a possible harvest aid.
- Develop better controls for perennial weeds (esp. field bindweed).
- Develop methods to stop growth of chickpeas in the fall (growth regulator or swathing).

Regulatory

- Harmonize pesticide registrations.

- Facilitate Section 3 registration of pyridate (Tough).
- Note that registrant response time is slow due to consolidation of registrants.
- Pursue Section 3 registration for clethodim (Select) on all 3 pulse crops.
- Pursue 2,4-DB registration for lentils.
- Pursue and obtain full crop insurance program.
- Maintain registration of paraquat (Gramoxone) as a harvest aid.

Education

- Educate growers on sprayer contamination, drift, PHI, timing of herbicide applications, and temperature sensitivity of different herbicides.
- Educate growers on the timeliness of pre-harvest burndown for crop quality.
- Educate growers, general public, and regulatory agencies on herbicide resistance management.
- Educate growers about optimal timing of harvest aids to minimize shatter.

DISEASES

Many pulse crop diseases are expressed during this crop stage but are treated in previous stages. For additional detail, refer to "Diseases" under the "Pre-plant" and "Planting" sections, above.

Root rot diseases, caused by *Rhizoctonia solani*, *Aphanomyces euteiches*, and different species of *Fusarium*, can limit root development and cause yield reductions in all of the pulse crops. *Fusarium* and *Rhizoctonia* have wide host ranges, therefore crop rotation alone may not provide complete control of the diseases caused by these pathogens. *Aphanomyces* produces a resting spore known as an "oospore" that remains viable in the soil for many years; thus crop rotation does not provide complete control of this disease, either. While partial resistance to *Aphanomyces* and some *Fusarium* species is available, most cultivars are susceptible. Fungicide seed treatments, discussed in the "Planting" section, can provide some protection against the seed and seedling blight phases of these diseases, but generally will not control the root rot phases, as the fungicide is no longer present at that phase of the crop cycle.

The Fusarium wilt pathogen, *Fusarium oxysporum*, infects the roots of pulse crops and enters the vascular system of the plants, causing the plant to wilt. Generally, symptoms are present in the internal root tissue (vascular discoloration), but not the external tissue. Cultivars differ in their susceptibility to Fusarium wilt, and fungicides do not control this disease.

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). 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).

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. Sclerotinia white mold causes mold on stems, leaves, and pods. 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.

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 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” subsection following.

Cultural Practices

Across all three pulse crops, growers follow the same general principles to manage Ascochyta blight. During the pre-plant planning phase, they practice a four-year crop rotation (i.e., three years between the same type of pulse crop). At planting, they select cultivars with the highest available levels of resistance and seed that is clean and has been tested in an accredited seed testing lab. During the emergence to harvest period, they scout their fields regularly.

Virus diseases are partially controlled in each of the three crops by controlling the aphids that vector these diseases.

In dry peas, growers scout for powdery mildew symptoms prior to application of sulfur.

In lentils, anthracnose is controlled in the same manner as Ascochyta.

For all pulses, selection of resistant varieties at planting is a key cultural strategy.

Chemical Controls
Azoxystrobin (Quadris, Amistar) or pyraclostrobin (Headline) are sometimes used for broad-spectrum disease control in pulses (particularly for Ascochyta), but the expense of these products limits their use. Clorothalanil (Bravo, others) and boscalid (Endura) are less effective, but still used in chickpea for resistance management.

Boscalid is also registered for use in lentil and chickpea for Botrytis and Sclerotinia (white mold), but due to high cost is not used.

In dry peas, if powdery mildew is found to be present, sulfur is applied.

Critical Needs for Management of Diseases in Pulse Crops from Emergence to Harvest:

Research
- 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 fungicide 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.
- Continue breeding for resistance to blight, Fusarium, root rots, and other diseases.
- Evaluate the susceptibility of pulse crops to soybean rust.

Regulatory
- Allow resistance management as a justification for obtaining Section 18s.
- Register prothioconazole (Proline) for all 3 pulse crops.
- Register azoxystrobin (Dynasty) for control of Ascochyta.

Education
- Educate growers, regulators, and general public about “snake oils.”
- Educate growers about development of fungicide resistance 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).
- Develop a list of varieties with accompanying disease ratings.
- Educate growers on the appearance of nutrient deficiency symptoms vs. that of disease symptoms.

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 “Shipping/Storage” section).

The pea leaf weevil (PLW, *Sitona lineata*) adult is also 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 problems in pulse crops, particularly lentils. Pea aphids (*Acyrthosiphon pisum*) cause direct as well as indirect damage to plants. Aphids feeding on plants can deplete plant vigor and result in plant death. Pea aphids also vector 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 have many hosts and 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.

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 dry peas in North Dakota and lentils in all growing regions. 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 dry peas and 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. 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. 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 pod formation 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 sufficient numbers to reduce pea weevil, pea leaf weevil, or aphid populations below economically damaging levels.

Chemical Controls

For pea weevil, if scouting reveals that the economic threshold has been reached, 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 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 to 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, 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. Several other 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 Pulse Crops from Emergence to Harvest:

Research

- Develop alternatives to pyrethroids.
- 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 systemic replacement for dimethoate.

Regulatory

- Expedite registrations for cutworm control in chickpea.
- Obtain registration of bifenthrin (Capture 2E) and other novel insecticides.
- Maintain dimethoate registration (as of 1/07, this use was retained on lentils for control of Lygus and aphid).

Education

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

VERTEBRATES
Rabbits and other foliage-eating vertebrates can pose problems in pulse crops, especially chickpeas. Elk, pronghorn antelope, and deer present a problem in some areas. Growers who swath have geese and duck problems. California growers have problems with theft of crop by humans who resell at farmer's markets.

Critical Needs for Management of Vertebrates in Pulse Crops from Emergence to Harvest:

Research
- Develop pest management solution to rabbit problems especially in chickpeas.
- Develop more effective vertebrate predation.

Regulatory
- More cooperation with Fish & Game jurisdictions; need wider parameters.

Education
- Educate Fish & Game agencies as to necessity of quick response and nature of problem.
- California chickpea growers may need to secure their fields.

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.

Cultural Practices
Growers keep equipment clean when introducing it into the field so as to minimize weed seed or propagule transmission. Growers will also observe, mark, and map perennial weed patches for future control. Residue management, such as making sure chaff rows are spread, is practiced. Some growers with very weedy fields will leave windrows to burn later.

Chemical Controls
Sodium chlorate is used as a desiccant, but is not particularly effective. 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 this as 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.

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.

Cultural Practices
Growers ensure that moisture levels are appropriate at harvest to avoid post-harvest disease issues. Seed from diseased plots is segregated to avoid contamination. Seed quality is monitored for marketing purposes. Effort is made to ensure no cross-contamination of varieties occurs.

Chemical Controls
No chemical controls are employed for diseases at harvest.

INSECTS

Insects are seldom controlled at the harvest stage.

Grasshoppers may be controlled shortly before harvest with malathion, which has a 1-day PHI, or with carbaryl (Sevin), which has a 21-day PHI.

Armyworms can be a crop contaminant in dry peas. Pyrethroids such as esfenvalerate (Asana, 21-day PHI) may be used or the worms may be cleaned from the harvested crop.

Critical Needs of Pulse Crops at Harvest:

Research
- Develop additional determinate chickpeas.
- Investigate cause of shatter problems in all pulses.
- Research safety of glyphosate (Roundup Ultra) application when using crop residue 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 traits (e.g., height) that could aid in harvest.

Regulatory

- Expand glyphosate (Roundup Ultra) label to allow for use on pulse crops when residue is intended as forage.

Education

- Educate growers about trash management in diseased fields.
- Educate growers about market restrictions resulting from the use of certain products (e.g., Roundup Ultra).

Post-harvest

Even though peas and chickpeas produce a limited amount of crop residue, they develop one of the best seedbeds for subsequent crops with direct seed cropping systems. The high N:C ratio of pulses provides a nitrogen benefit to non-legume crops in the system and reduces the need for N fertilizer application.

All operations listed here take place in the field following removal of the crop. Typical operations include: application of perennial weed controls, heavy harrowing to manage residue in some regions (not prevalent in Regions 1 and 3 as is not acceptable to NRCS because of erosion and air quality issues), fertilization for the next season's crop, and pre-plant chemical application and incorporation for the next crop.

Sampling for certified seed also takes place at this time.

Critical Needs of Pulse Crops at Post-harvest

Research

- Research chickpea, pea and lentil contributions to following crops, including nitrogen and carbon credits.
- Develop better tools for perennial weed control.
- Research field operations that are not detrimental to air quality.
- Continue varietal research for higher crop residue (greater biomass) in lentils (to reduce erosion).

Regulatory

- Expand use of treated crop residue as forage.

Education

- Educate growers on plant-back restrictions of pesticides used in pulse production.
- Educate regulators about the value of pulses in rotation systems.

Shipping/Storage

This production stage is defined as the activities done after the crop leaves the field and prior to consumption. This stage includes warehousing.

Seed moisture must be carefully watched during storage of pulses to prevent storage molds, spoilage, heat damage, insect damage, and unintentional germination. Peas, lentils, and chickpeas are stored at <12.5% moisture in Region 1. Peas are stored at <13-14 percent moisture in Regions 3 and 4. Chickpeas and lentils should be stored at <14 percent moisture. (Refer to USDA regional grade standards.) Moisture is tested several times during the first few weeks of storage to maintain proper levels and to prevent seed sweating. If moisture levels are too high, bin aeration may be employed. Aeration cools and dries the seed to forestall storage problems. It is important to make sure the fan size is appropriate to the bin size and the crop. Grain dryers are sometimes used on chickpea, but they must be used with extreme caution because they may cause mechanical and thermal damage to the crop.

The pea weevil *(Bruchus pisorum)* often shows up as a problem during the post-harvest stage, but control must take place while the crop is still in the field (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 Pulse Crops During Shipping/Storage:

Research

- Develop cost-effective fumigation controls; alternatives to aluminum phosphide (Phostoxin).
- Develop separation methods of pea-weevil-infested peas.
- Develop weevil-resistant pea varieties.
- Research elimination of chalky spot on peas and lentils, including resistant varieties.
- Find alternatives to methyl bromide for fumigation.

Regulatory

- Work to harmonize MRLs internationally.
- Harmonize regulations in pulse crops grown for seed production.
- More collaboration with other countries over phytosanitary export issues.

Education

- Investigate a variety of niche marketing (GMO, non-GMO, organic) opportunities.
- Educate growers about moisture content, monitoring, and aeration procedures to reduce damage during storage.

For More Information

This document was designed to report the perspectives of the pulse growers of California, Idaho, Montana, Nebraska, North Dakota, South Dakota and Washington. 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 contact:

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

APPENDICES

NOTE:

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.

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	3					3	3	1,3	1,3
Sample Soil			3	3	3				3	3	3	
Fertilize				3	3	3			3	3	3	
Irrigate						3	3	3	3			
Inoculate			1	1,3	1,3	3						
Plant			1	1,3	1,3	3						
Roll			1	1,3	1,3	3						
Swath								3	3	3		
Mechanical Harvest								1,3	1,3	1,3	1	

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
Treat Seed		1	1,3	1,3	3							
Apply Herbicide			1	1,3	1,3	1,3	3	3	3	3		
Cultivate Mechanically*			1	1,3	1,3	3			3	3		
Apply Fungicide				1	1,3	1,3	3	3				
Scout Pests			1,3	1,3	1,3	1,3	1,3	1,3	1,3			
Apply Insecticide				3	3	1,3	1,3	3	3			
Apply Spot Herbicide					3	3	1,3	1				
Rogue Weeds						1	1,3	3				
Apply Harvest Aid								1,3	1,3	3		

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

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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			1	1	3	3	1,3	1,3
Sample Soil			3	3					3	3	3	
Fertilize			3	3	3				3	3		
Irrigate					3	3	3	3	3			
Inoculate			1,3	1,3	1,3	1		1	1	1,3		
Plant			1,3	1,3	1,3	1,3		1	1	1,3		
Roll				1,3	1,3	1,3						
Test Petioles						3						
Swath						1	1,3	1,3				
Mechanical Harvest							1,3	1,3	3			

Note: Information based on grower and pest control advisor experience. Includes both fall and spring lentils.

Pest Management Activities and Crop Monitoring Profile

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Treat Seed		1,3	1,3	1,3	3			1	1			
Apply Herbicide			1,3	1,3	1,3	1,3	3	3	1,3	1,3	1	
Cultivate Mechanically*			1	1,3	1,3			1	1	1,3	3	
Scout Pests		1	1,3	1,3	1,3	1,3	1,3	1,3	1	1	1	1
Apply Spot Herbicide				3	3	1,3	1,3	3	1,3			
Apply Fungicide					1,3	1,3	3					
Apply Insecticide				1,3	1,3	1,3	1,3	3	3			
Rogue Weeds						1,3	1,3					
Apply Harvest Aid							1,3	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, 3, and 4

Cultural Activities

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Clean Seed	1,3,4	1,3,4	1,3,4	1,3,4			1	1,3,4	3,4	3,4	1,3,4	1,3,4
Sample Soil			3,4	3,4					3,4	3,4		
Fertilize			3,4	3,4	3,4	3,4			3,4	3,4		
Irrigate*						3	3	3	3			
Inoculate			1,3,4	1,3,4	1,3,4	3,4		1	1	3,4		
Plant			1,3,4	1,3,4	1,3,4	3,4		1	1,3,4			
Roll			1,3,4	1,3,4	1,3,4	3,4		1	1			
Test Petioles†						3,4						
Swath						1	1,3,4	3,4	3			
Mechanical Harvest						1	1,3,4	1,3,4	1,3,4			

Note: Information based on grower and pest control advisor experience. Includes Fall and spring dry peas.
* 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
Treat Seed		1	1,3,4	1,3,4	3,4							
Apply Herbicide			1,3,4	1,3,4	1,3,4	1,3,4	3,4	1,3,4	1,3,4	1,3,4		
Cultivate Mechanically*		1	1,3,4	1,3,4	1,3,4			1	1	1		
Scout Pests	1	1	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1	1	1	1
Apply Insecticide		1	1	1	1,3,4	1,3,4	1,3,4	3,4	1	1		
Apply Fungicide				1	1	1,3,4	1,3,4					
Apply Spot Herbicide					3,4	1,3,4	1,3,4	3,4	3,4			
Rogue Weeds						1,3,4	1,3,4					
Apply Harvest Aid						1	1,3,4	1,3,4	3			

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

Activity Tables for Chickpeas Grown in Region 5

Cultural Activities

Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Clean Seed						X	X	X				
Sample Soil									X	X		
Fertilize										X	X	X
Irrigate*			X	X	X							
Inoculate									X	X		
Plant	X	X								X	X	X
Roll												
Test Petioles ‡		X	X									
Swath (rescue only)						X						
Mechanical Harvest						X	X					

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												
Treat Seed									X	X	X	
Apply Herbicide	X	X							X	X	X	
Cultivate Mechanically*												
Apply Fungicide		X	X	X	X							
Scout Pests			X	X	X							
Apply Insecticide				X	X							
Apply Spot Herbicide												
Rogue Weeds				X	X							
Apply Harvest Aid						X						

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

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Efficacy Tables for Herbicides

This page covers pre-plant and pre-emergence applications and IPM/cultural strategies on weed pests A-L	PREPLANT/PRE-EMERGENCE MANAGEMENT TOOLS												IPM/CULTURAL				
	carfentrazone (Aim)	dimethenamid, dimethenamid-(Frontier 6EC/ Outlook)	ethalfluralin (Sonalan)	glyphosate (Roundup Ultra)	imazethapyr (Pursuit)	s-metolachlor (Dual Magnum, ual II Magnum)	metribuzin (Sencor, Lexone)	oxyfluorfen (Goal)	pendimethalin (Prowl)	sulfentrazone (Spartan)	triallate (Far Go, Avardex BW)	trifluralin (Treflan)	Crop Rotation	Seedbed Prep	Clean Fields	Scouting	Pre-plant Cultivation
(P)ea, (L)entil, (C)hickpea	**PLC**	**LC**	**PC**	**PLC**	**PLC**	**PLC**	**PLC**	**C**	**PLC**	**PC**	**PLC**	**PLC**	**PLC**				
barley, volunteer	**Poor results pre-plant, but useful for burn-down at pre-emergence (not in CA) if glyphosate was not used or was insufficient**	**P**	**P**	**E**	**F-G**	**E**	**P**	**P**	**P**	**P**	**N/A**	**F**	**Used by all growers on all three crops.**				
barnyardgrass		**E**	**E**	**E**	**P**	**E**	**N/A**	**P**	**G-E**	**F**	**N/A**	**E**					
Canada thistle		**N/A**	**N/A**	**P-G †**	**P**	**N/A**	**P**	**P**	**N/A**	**N/A**	**N/A**	**N/A**					
chickweed, common		**P**	**G-E**	**G**	**G-E**	**G**	**F**	**P**	**F-G**	**F**	**N/A**	**E-G**					
chickweed, mouseear		**P**	**P**	**P-G †**	**G**	**P**	**P**	**P**	**N/A**	**P**	**N/A**	**N/A**					
clover		**P**	**P**	**F-G**	**P**	**N/A**	**P**	**E**	**N/A**	**P**	**N/A**	**N/A**					
cocklebur, common		**P**	**P**	**G**	**G**	**P**	**F**	**N/A**	**P**	**N/A**	**N/A**	**N/A**					
corn, volunteer		**P**	**P-F**	**E §**	**G**	**P**	**N/A**	**P**	**P**	**N/A**	**N/A**	**P-F**					
cornflower		**P**	**P**	**G**	**F**	**P**	**P-F**	**N/A**	**P-F**	**F**	**N/A**	**N/A**					
cow cockle		**P**	**G-E**	**G-E**	**F**	**P**	**P**	**N/A**	**P-F**	**F**	**N/A**	**G-E**					
crabgrass		**G**	**N/A**	**E**	**P-F**	**E**	**N/A**	**P**	**G-E**	**P**	**N/A**	**G-E**					
dandelion		**P**	**N/A**	**F**	**N/A**	**P**	**P**	**F**	**N/A**	**N/A**	**N/A**	**N/A**					
downy brome		**P**	**F-G**	**E**	**P-F**	**G**	**P-F**	**P**	**P**	**N/A**	**F-G**	**F**					
flixweed		**P**	**P**	**F-G**	**E**	**P**	**F-G**	**P**	**P**	**F**	**N/A**	**N/A**					
foxtail barley		**P**	**N/A**	**G-E**	**P**	**N/A**	**N/A**	**P**	**P**	**N/A**	**N/A**	**N/A**					
foxtail, green		**G**	**G-E**	**E**	**G-E**	**E**	**G**	**P**	**E**	**F**	**N/A**	**E**					
foxtail, yellow		**G**	**G**	**E**	**G-E**	**G-F**	**N/A**	**P**	**E**	**F**	**N/A**	**E**					
Gallium spp.		**P**	**P**	**F-G**	**G**	**P**	**P-F**	**P**	**P**	**P**	**N/A**	**N/A**					
gromwell, corn		**P**	**N/A**	**G**	**F**	**P**	**P-F**	**P**	**P**	**F**	**N/A**	**N/A**					
henbit		**P**	**N/A**	**G**	**F**	**P**	**P-F**	**E**	**P-F**	**F**	**N/A**	**N/A**					
horseweed/Canada fleabane		**P**	**P**	**P-F**	**F**	**P**	**F-G**	**G**	**P**	**P**	**N/A**	**N/A**					
Italian ryegrass		**P**	**G**	**E ‡**	**P-F**	**F-G**	**P**	**P**	**G**	**N/A**	**N/A**	**G-E ‡**					
jointed goatgrass		**P**	**G**	**E**	**P-F**	**F-G**	**P**	**N/A**	**P-F**	**N/A**	**N/A**	**P-F**					
knotweed, common		**P**	**F-G**	**F**	**G**	**P-F**	**P-F**	**E**	**G**	**F**	**N/A**	**G-E**					
kochia		**P**	**F-G**	**P-F #**	**P-E ‡**	**P**	**F-G**	**P-F**	**P-F**	**E**	**N/A**	**P-F**					
lambsquarter		**F**	**G**	**G**	**F-E**	**F**	**F-G**	**E**	**G**	**G**	**N/A**	**P-G**					

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control), P = Poor (less than control), N/A= not used against this weed pest.

† 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.

Efficacy Tables for Herbicides

This page covers pre-plant and pre-emergence applications and IPM/cultural strategies on weed pests M-Z	PREPLANT/PRE-EMERGENCE MANAGEMENT TOOLS												IPM/CULTURAL				
	carfentrazone (Aim)	dimethenamid, dimethenamid-P (Frontier 6EC/ Outlook)	ethalfluralin (Sonalan)	glyphosate (Roundup Ultra)	imazethapyr (Pursuit)	s-metolachlor (Dual Magnum, Dual II Magnum)	metribuzin (Sencor*, Lexone)	oxyfluorfen (Goal)	pendimethalin (Prowl)	sulfentrazone (Spartan)	triallate (Far Go, Avardex BW)	trifluralin (Treflan)	Crop Rotation	Seedbed Prep	Clean Fields	Scouting	Pre-plant Cultivation
(P)ea, (L)entil, (C)hickpea	PLC	LC	PC	PLC	PLC	PLC	PLC	C	PLC	PC	PLC	PLC	PLC				
marshelder	Poor results pre-plant, but useful for burn-down at pre-emergence (not in CA) if glyphosate was insufficient	P	N/A	G	F	P	P-F	P-F	N/A	F	N/A	P	Used by all growers on all three crops.				
mayweed chamomile (dog fennel)		F	P	F-G	P	F	F-G	G	P	G-E	N/A	P					
mustard, tall		P	P-F	F-G	E	P	F-G	G	P	F	N/A	P					
narrowleaf hawksbeard											N/A						
nightshade, black		P	P	F-G	G-E	P	P-G	G	P	E	N/A	P					
nightshade, hairy		P	P-F	F-G	G-E	P	P-G	G	P	E	N/A	P					
oat, volunteer		P	F-G	E	P-F	P	P	P	P	N/A	E	P-F					
oat, wild		P	F-G	G-E	P-F	P	P	P	P	N/A	G-E	P-F					
pennycress, field		P	N/A	F-G	G-E	P	F-G	P	P	P	N/A	P					
pigweed, prostrate		G	G	F-G	G-E	G-E	G	G	G	G-E	N/A	G					
pigweed, redroot		G	G	F-G	G-E	G-E	G	G	G	G-E	N/A	G					
prickly lettuce		P	P	P-F	P-F	P-F	G	G	P-F	P-F	N/A	P					
purslane, common		P	E	P-G	P-G	G	P	G	G	N/A	N/A	G					
quackgrass		N/A	N/A	G-E †	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
ragweed, common		P	P	F	P	P-F	P-G	G	P	F	N/A	P					
redstem filaree		P	G	G	G	F	P-F	G	F-G	F	N/A	F					
Russian thistle		P	P-F	P-F #	E ‡	F-G	P	P-F	P	E	N/A	G					
shepherdspurse		P	N/A	G-E	E	P-F	P-F	G	P	P	N/A	P					
smartweed		P	P	G-E	G	P-F	P-F	G	P	P	N/A	P					
sowthistle, annual		P	N/A	P-F	P-F	P-F	F-G	G	P	F	N/A	P					
vetch		P	P	F-G	P	P	F	G	P	P	N/A	P					
volunteer canola		P	N/A	F-G §	E §§	P-F	P	P-F	N/A	P	N/A	P					
wheat, volunteer		P	F-G	E	F	P-F	N/A	P	P	P	N/A	F-G					
wild buckwheat		P	P-F	F-G	P	P-F	E	G-E	P	F	N/A	P					
wild mustard		P	N/A	F-G	E ‡	P-F	P-F	F-G	P	P-F	N/A	P					
wild radish		P	N/A	G	G	P-F	P	F-G	P	P	N/A	P					
wild sunflower		P	N/A	F-G	P	N/A	F-G	F	P	P	N/A	P					
yellow rocket		P	N/A	F-G	E	P-F	P	P-F	P	P	N/A	P					

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control), P = Poor (less than 60% control), N/A= not used against this weed pest.

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

† 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.

Efficacy Tables for Herbicides

This page covers post-emergence tools for weed pests A-L

	POSTEMERGENCE MANAGEMENT TOOLS												
	metribuzin (Sencor*, Lexoı	bentazon (Basagran)	quizalofop P-ethyl (As	paraquat dichloride ** (Gramoxone Extra)	sethoxydim (Poast)	MCPB (Thistrol)	pronamide (Kerb) (winter p fall applied pre-emer	sodium salt of MCPA or PC amine (Chiptox)	imazamox/bentazon (Raptor/Basagran)	carfentrazone-ethyl **(Aim	clethodim (Select)	imazethapyr (Pursuit)	2,4-DB ***
(P)ea, (L)entil, (C)hickpea	**PCL**	**P**	**PCL**	**PL**	**PCL**	**P**	**P**	**P**	**P**	**C**	**C**		**L**
barley, volunteer	P	N/A	E	G	E	N/A	E	N/A	F-G	N/A	E	Registered but ineffective, therefore little used	N/A
barnyardgrass	P	N/A	E	G	E	N/A	E	N/A	G	N/A	E		N/A
Canada thistle	F	F-G†	N/A	F	N/A	F-G	N/A	P	F-G	P-F	N/A		F
chickweed, common	P-F	P	N/A	G-E	N/A	F	N/A	F	F	F-G	N/A		G
chickweed, mouseear	P	P	N/A	G-E	N/A	P	N/A	P	F	F-G	N/A		P
clover	P	N/A	N/A	F	N/A	P	P	P	N/A	P-F	N/A		
cocklebur, common	F-G	E	N/A	G-E	N/A	F-G	N/A	F	G	F-G	N/A		G
corn, volunteer	N/A	N/A	E	G-E	E	N/A	E	N/A	G	N/A	E		N/A
cornflower	P	P	N/A	G-E	N/A	P	N/A	F	G	F-G	N/A		F
cow cockle	P	P	N/A	G-E	N/A	P	N/A	F	G	F-G	N/A		F
crabgrass	N/A	N/A	G	F	E	N/A	E	N/A	E	N/A	E		N/A
dandelion	P	F	N/A	G-E	N/A	F-G	N/A	F	G	F-G	N/A		F
downy brome	P	N/A	G-E	F	G	N/A	E	N/A	G	N/A	G-E		N/A
flixweed	P	G-E	N/A	G-E	N/A	F	N/A	F	G	N/A	N/A		F
foxtail barley	P	N/A	G	F	G	N/A	N/A	N/A	F	N/A	E		N/A
foxtail, green	F	N/A	E	G	E	N/A	E	N/A	G	N/A	E		N/A
foxtail, yellow	P	N/A	E	G	F-E	N/A	E	N/A	G	N/A	E		N/A
Gallium spp.	P	P	N/A	F-G	N/A	P	N/A	P	G	G	N/A		F
gromwell, corn	P	P	N/A	G-E	N/A	F	N/A	F	G	P-F	N/A		F
henbit	P	P	N/A	G-E	N/A	F	N/A	F	G	P-F	N/A		F
horseweed/Canada fleabane	F	F-G	N/A	G-E	N/A	F	N/A	F	G	F-G	N/A		G
Italian ryegrass	P	N/A	E	F-G	E	N/A	G	N/A	G	N/A	E		N/A
jointed goatgrass	P	N/A	G-E	F	G-E	N/A	G	N/A	G	N/A	G-E		N/A
knotweed, common	P	P-F	N/A	G-E	N/A	F	N/A	F	G	F-G	N/A		F
kochia	F	P	N/A	G	N/A	P	N/A	P	G ‡	F-G	N/A		F
lambsquarter	P	F-G	N/A	E	N/A	G	N/A	G	G-F	G-E	N/A		G

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control), P = Poor (less than 60% control), N/A= not

* When used post-emergence, Sencor causes greater crop injury and is less efficacious on target weeds.
** Registered but not used on chickpea (because it's labeled for hooded sprayer only)
† 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.

Efficacy Tables for Herbicides

This page covers post-emergence tools for weed pests M-Z

	POSTEMERGENCE MANAGEMENT TOOLS												
	metribuzin (Sencor*, exone)	bentazon (Basagran)	quizalofop P-ethyl ssure II)	paraquat dichloride (Gramoxone Extra)	sethoxydim (Poast)	MCPB (Thistrol)	pronamide (Kerb) winter peas - fall plied pre-emerge)	sodium salt of MCPA or PCPA amine Chiptox)	carfentrazone-ethyl *(Aim)	clethodim (Select)	imazamox/bentazon Raptor/Basagran)	imazethapyr (Pursuit)	2,4-DB ***
(P)ea, (L)entil, (C)hickpea	PCL	P	PCL		PCL	P	P	P	C	C	P		L
marshelder	F-G	G	N/A	G	N/A	F	N/A	F	Registered as a desiccant, but new so not much data	N/A	G	Registered but ineffective, therefore little used	G
mayweed chamomile (dogfennel)	P	G-E	N/A	G-F	N/A	F	N/A	F		N/A	F-G		G
mustard, tall	F-G	P	N/A	G	N/A	F	N/A	F		N/A	G		F
narrowleaf hawksbeard			N/A	G	N/A	P	N/A			N/A			
nightshade, black	P	F	N/A	G-E	N/A	F	N/A	F		N/A	E		G
nightshade, hairy	P	F	N/A	G-E	N/A	F	N/A	F		N/A	E		G
oat, volunteer	P	N/A	E	G	G-E	N/A	E	N/A		E	E		N/A
oat, wild	P	N/A	G-E	G	G-E	N/A	E	N/A		G-E	E		N/A
pennycress, field	F	G	N/A	G	N/A	F	N/A	F		N/A	E		G
pigweed, prostrate	F	F	N/A	G-E	N/A	F	N/A	F		N/A	E		F
pigweed, redroot	F	F	N/A	G-E	N/A	F	N/A	F		N/A	F		F
Poa annua	F	N/A	G	G-E	G	N/A	F	N/A		G			
prickly lettuce	F-G	F-G	N/A	G	N/A	F	N/A	F		N/A	F-G		F
purslane, common	P	P	N/A	F-G	N/A	P	N/A	P		N/A	F		P
quackgrass	P	N/A	P-E	P	P-F	N/A	N/A	N/A		F-G	N/A		N/A
ragweed, common	F-G	F-G	N/A	G	N/A	F	N/A	F		N/A	E		G
redstem filaree	F	P	N/A	G	N/A	G	N/A	F		N/A	E		G
Russian thistle	F	F-G	N/A	G ##	N/A	F	N/A	F		N/A	G ‡		P
shepherdspurse	F-G	P	N/A	G	N/A	F	N/A	F		NA	E		F
smartweed	P	E	N/A	G	N/A	F	N/A	F		NA	G		P
sowthistle, annual	P-F	G	N/A	G	N/A	F	N/A	F		NA	G		F
vetch	P	N/A	N/A	G	N/A	E	N/A	P		NA			
volunteer canola	P	P	N/A	G-E	N/A	F	N/A	F		NA	E §§		F
wheat, volunteer	P	N/A	E	G	E	N/A	E	N/A		E	G §§		N/A
wild buckwheat	G	P	N/A	F-G	N/A	F	N/A	F		N/A	F		P
wild mustard	P-G	P-E	N/A	G-E	N/A	F-E	N/A	F		N/A	E		F
wild radish	P-G	P	N/A	G	N/A	F	N/A	F		N/A	G		F
wild sunflower	P-F	P-G	N/A	G	N/A	G	N/A	G		N/A	G		F
yellow rocket	P	P	N/A	G	N/A	F	N/A	F		N/A	G		F

E = Excellent (greater than 90% control), G = Good (80-90% control), F = Fair (60-80% control), P = Poor (less than control), N/A= not used against this weed pest.

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

** Registered but not used on chickpea (because it's labeled for hooded sprayer only).

*** In the registration pipeline.

† 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.

Efficacy Table for Fungicides on Chickpeas

MANAGEMENT TOOL	Ascochyta blight (*Ascochyta rabiei*)	*Botrytis* spp.	*Fusarium* spp.	*Pythium* spp.	*Rhizoctonia spp.*	*Sclerotinia spp.*	Comments
azoxystrobin (Quadris)	G	?	N	N		N	
azoxystrobin (Dynasty)*	G	N	F	N	G	N	
boscalid (Endura)	F	G	N	N	N	G	important for resistance nanagement
captan (Captan)*	N	N	F	N	F	N	
fludioxanil (Maxim)*	N	?	G	N	G	F	
mefenoxam (Apron XL) + netalaxyl (Allegiance)*	N	N	N	G	N	N	
pyraclostrobin (Headline)	G	?	N	N		N	
Section 24c Products							
chlorothalonil (Bravo) - WA	F	N	N	N	N	N	important for resistance nanagement
thiabendazole (Mertect) - WA, D, MT	G	?	F-G	N	?	?	
Pipeline Materials							
prothioconazole (Proline)	G	?	N	N	N	G	
IPM and Cultural Control							
crop rotation	Y	Y	Y	Y	Y	Y	
disease-free seed (seed testing)	Y	Y	N	N	N	Y	
field selection	generally considered important in disease management						
increased distance between elds	Y	N	N	N	N	Y	
partially resistant varieties	Y	N	Y	N	N	N	
row spacing	Y	Y	N	N	N	Y	
scouting	Y	Y	N	N	N	Y	
seeding rate	Y	Y	N	N	N	Y	

Efficacy rating symbols: E=Excellent (90-100% control), G=Good (80-90% control), F=Fair (70-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 sistant varieties, no non-chemical control measure will stand alone.

* Seed treatment

Efficacy Table for Fungicides on Lentils

MANAGEMENT TOOL	Anthracnose (*Colletotrichum truncatum*)	Ascochyta blight (*Ascochyta lentis*)	bean (pea) leaf roll virus (BLRV)	*Botrytis* spp.	*Fusarium* spp.	pea enation mosaic virus (PEMV)	*Pythium* spp.	*Rhizoctonia* spp.	*Sclerotinia* spp.	Comments
azoxystrobin (Dynasty)	?	?	N	?	F	N	N	G	?	
azoxystrobin (Quadris, Amistar)	G	G	N	?	N	N	N		N	
boscalid (Endura)	N	F	N	G	N	N	N	N	G-E	
captan (Captan 400)	N	N	N	N	F	N	N	F	N	Can inhibit Rhizobia inoculant
fludioxonil (Maxim)	N	N	N	?	G	N		G	G-E	
mefenoxam (Apron XL)	N	N	N	N	N	N	G	N	N	
pyraclostrobin (Headline)	G	G	N	?	N	N	N		N	
Section 18 Products										
thiabendazole (LSP flowable, Mertect LSP)(WA, MT, ND)		G		?						
Pipeline Materials										
prothioconazole (Proline)	?	G	N	?	N	N	N		G	
IPM and Cultural Control										
clean seed		Y			N		N	N	Y	
crop rotation		Y			Y		Y	Y	Y	
field selection	Generally considered important in disease management									
seedbed preparation		Y			Y		Y	Y	N	
testing seed for Ascochyta blight		Y								
use of certified seed		Y/N			N		N	N	N	
use of systemic insecticides to control aphids			Y			Y				
well drained soils		N			Y		Y	Y	N	

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	***Aphanomyces euteiches***	**Foot rot (*Ascochyta pinodella*)**	**Ascochyta blight (*Ascochyta pisi, Mycosphaerella pinodes*)**	**Powdery mildew (*Ersiphe pisi*)**	**Seedling blight (*Fusarium*)**	**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
azoxystrobin (Dynasty)*	N	?	?		F	N	?	N	G	N	N	N	
azoxystrobin (Quadris)	N	N	G	G	N	N		N			N	N	
captan (Captan 400)*	N	N	N	N	F	N	N	N	F	N	N	N	may be antagonistic to Rhizobia inoculant
fludioxonil (Maxim)*	N	?	?		G	N			G	G	N	N	
mefenoxam (Apron XL)*	N	N	N		N	N	G	G			N	N	
metalaxyl (Allegiance)*	N	N	N		N	N	G	G			N	N	
PCNB*	N	?	?			N		N	G	N	N	N	may be antagonistic to Rhizobia inoculant
pyraclostrobin (Headline)	N	N	G	G	N	N		N			N	N	
thiram (Thiram 75WP)*	N	?	?		F	N		N	F	F	N	N	
sulfur (various trade names)	N	N	N	G	N	N	N	N	N	N	N	N	
Pipeline Materials													
prothioconazole (Proline)		N	G	G		N		N		G	N	N	
IPM and Cultural Control													
certified seed	N	N	N	N	N	N	N	N	N	N			
clean seed	N	N	Y	N	N	N	N	N	N	N			
control aphids/leafhoppers											Y	Y	
crop rotation	Y	Y	Y	Y	Y	Y	N	Y	Y	Y			
field selection	generally considered important in disease management												
resistant cultivars	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	
seed vigor	Y	Y	N	N	Y	N	N	Y	Y	N			
seedbed preparation	Y	Y	Y	N	Y	N	N	Y	Y	N			
testing seed for Ascochyta blight			Y	N									
well drained soils	Y	Y	N	N	N	N	N	Y	Y	N			

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.

* seed treatment

Efficacy Table for Insecticides on Chickpeas

MANAGEMENT TOOL	Alfalfa loopers	Armyworms	Aphids	Cutworm, pale western	Cutworm, redbacked	Grasshoppers	Wireworms (*Limonius* spp.)	Comments
Insecticides								
esfenvalerate (Asana)	E	E				E		Costly; only used 2 out of every 8 years.
dimethoate (Cygon)	E	P				E		
Pipeline Materials								
imidacloprid (Provado)	?	?	E			?		
IPM and Cultural Control								
bioassay fields							?	Can be useful for wireworm
habitat disturbance (e.g. cultivate/mow)								Not practiced.
Candidates for New Solutions								
Decis, Gaucho, Pounce, Helix, Matador	#1 Priority							
Gaucho, Helix	#2 Priority							Need new control measure.
Lorsban, Decis, Matador	#3 Priority							

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

Efficacy Table for Insecticides on Lentils

MANAGEMENT TOOL	Grasshopper	Lygus bug (*Lygus hespeus*and *L. elisus*)	Pale western cutworm	Pea aphid (*Acyrthosiphum pisum* (Harris))	Redbacked cutworm	Wireworm (*Limonius* spp.) *	Comments
Insecticides							
carbaryl (Sevin)	G	P		N/A		N/A	
dimethoate (Cygon)		E		E		N/A	Product of choice, others less efficacious and require tank mixing.
disulfoton (Di-Syston)		?		N/A		N/A	
endosulfan		F-G		F		N/A	
esvenvalerate (Asana)		F-G		N/A		N/A	Requires tank mixing; too expensive.
lindane		N/A		N/A		E	Under scrutiny; may phase out.
malathion	G	P(rs)		P(rs)		N/A	
methomyl (Lannate)		E		E		N/A	Costly.
methyl parathion (Penncap-M)		E		E		N/A	Bee safety is an issue.
IPM and Cultural Control							
bioassay field						?	Can be useful in wireworm
scouting	G	G	F	G	F	P	
economic thresholds	G		G		G		
maintain forder habitat for beneficials				?			
supplemental predator release		?					
habitat disturbance	P		P		P		e.g., cultivate/mow.
Pipeline Materials and Possible Biologicals							
bifenthrin (Capture 2E)		E(rs)		E		N/A	
cyfluthrin (Baythroid)		E		E		N/A	
cyfluthrin + imidacloprid (Legend)		E		E		N/A	
lambda-cyhalothrin (Warrior)		E		E		N/A	
thiamethoxam (Actara 25 WP)		E		E		N/A	Foliar spray.
thiamethoxam (Helix)		E		E		?	Seed treatment.

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, N/A = not applicable

* Wireworms are the highest priorityinsect pest in lentils for developing new solutions. Gaucho and Helix are currently candidate compounds under consideration.

(rs) = resistance concerns

MANAGEMENT TOOL, PART 1: INSECTICIDES (BIOCONTROL, IPM, AND PIPELINE MATERIALS ON NEXT PAGE)	**Armyworm**	**Cowpea aphid (*Aphis craccivora*)**	**Grasshoppers**	**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)		**N/A**		**G**			**N/A**		**N/A**		**N/A**	
chlorpyrifos (Lorsban)			**G**		**F-G**	**F**	**G**			**F**		
dichloropropene (Telone II)		**N/A**		**N/A**			**N/A**	**N/A**	**N/A**		**?**	
dimethoate (Cygon)		**E**		**E**			**G-E (r)**	**E**	**G**		**N/A**	1/2 lb ai on pea weevil.
disulfoton (Di-Syston)												Not used.
esfenvalerate (Asana)	**G**	**F**		**F**			**F**	**F**	**P**		**N/A**	Not cost efficient.
lindane		**N/A**		**N/A**			**N/A**	**N/A**	**N/A**			May be phased out.
malathion		**P(rs)**	**G**	**P(rs)**		**F**	**G-P(rs)**	**P(rs)**	**P(rs)**	**F**		Phytotoxic.
methoxychlor		**N/A**		**N/A**			**N/A**	**G**	**N/A**		**N/A**	Secondary pest outbreaks, not used alone.
phosmet (Imidan)		**G**		**G**				**G**	**E(c)**		**N/A**	
spinosad (Success)		**?**		**?**			**?**	**?**	**?**		**?**	
zeta-cypermethrin (Mustang)		**?**		**?**			**?**	**?**	**?**		**?**	

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, N/A = Not applicable.

(rs) = resistance concerns
(c) = tank mix
(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)	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			**?**		**N/A**			**N/A**	**N/A**	**N/A**		**N/A**	
Pipeline Materials and Possible Biologicals													
Aphidious ervi *								**?**					Parasitic wasp; research needed.
bifenthrin (Capture)		**E**			**E**			**E**	**E**	**E**		**N/A**	
lambda-cyhalothrin (Warrior)		**E**			**E**			**E**	**E**	**E**		**N/A**	
thiamethoxam (Actara 25WP, foliar spray)		**E**			**E**			**E**	**E**	**E**		**N/A**	
thiamethoxam (Helix, seed treatment)								**P***		**P***		**E**	*Aphids generally appear at time of 7th node, also stage the seed treatment stops working.
IPM and Cultural Control													
bioassay field												**?**	Can be useful in wireworm
crop rotation		**G**			**G**			**G**	**G**	**G**		**G**	
scouting		**E**	**G**	**G**	**E**	**P-G**	**G**	**P-E**	**E**	**E**	**G**	**E**	
delay planting									**F**				
economic thresholds		**E**	**G**		**E**		**F-G**	**P-E**		**E**	**F-G**	**E**	With virus could be updated.
maintain border habitat for predators		**?**						**?**					
habitat disturbance (e.g., cultivate/mow)			**P**				**P**				**P**		Not used in direct seeding systems.
supplemental predator release		?						**?**					
trap crop planted										**?**			Not used in direct seeding systems.
Candidates for New Solutions	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, N/A = Not applicable.

Seasonal Pest Occurrence by Regions - Chickpeas													
Weeds		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
barley, volunteer	Present	5	1,5	1,5	1,3,5	1,3	1,3				5	5	5
	Treated	5	5	1,5	1,5	1,3	1,3	3			5	5	5
barnyardgrass	Present				1,5	1,3,5	1,3,5	3,5					
	Treated			1	1,5	1,3,5	1,3,5	3,5					
Canada thistle	Present	1	1	1	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1	1
	Treated				3	3	1,3	1,3	1,3	1,3	1,3	1	
chickweed, common	Present	5	1,5	1,5	1	1					5	5	5
	Treated	5	5	1,5	1	1					5	5	5
bur clover	Present	5	5	5							5	5	5
	Treated	5	5	5							5	5	5
cocklebur, common	Present					5	5	5	5				
	Treated												
corn, volunteer	Present					3	3						
	Treated					3	3						
cornflower	Present				1	1	1	1					
	Treated				1	1	1	1					
cow cockle	Present		1	1	1	1							
	Treated				1	1							
dandelion	Present		1	1		3	3	3	3	3	3		
	Treated		1	1		3	3			3	3		
downy brome	Present	1,5	1,5	1,3	1,3	1,3	1			3	1,3,5	1,5	1,5
	Treated	5	1,5	1,	1,3	1,3				3	1,3,5	1,5	5
field bindweed	Present	3	3	3	3	3	3	3	3	3	3	3	3
	Treated				3	3	3		3	3	3		
flixweed	Present		1	1	1	1	1						
	Treated		1	1	1	1	1						
foxtail barley	Present				3	3	3	3	3	3	3		
	Treated				3	3	3			3	3		
foxtail, green	Present				1,3	1,3	1,3	3					
	Treated			1	1	1,3	1,3						
foxtail, yellow	Present				1,3	1,3	1,3	3					
	Treated			1	1	1,3	1,3						
Gallium spp.	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1		
gromwell, corn	Present		1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1				1		
hare barley	Present	5	5	5							5	5	5
	Treated	5	5	5							5	5	5
henbit	Present	1,5	1,5	1,5	1	1					1,5	1,5	1,5
	Treated	5	1,5	1,5	1	1				1	1,5	5	5
horseweed/ Canada fleabane	Present	1,3	1,3	1,3	1,3	1,3	3	3	3	3	1,3	1,3	1,3
	Treated			1	1,3	1,3				3	3		
Italian ryegrass	Present	1,5	1,5	1,5	1	1	1	1			1,5	1,5	1,5
	Treated	5	5	1,5	1	1	1			1	1,5	1,5	5
jointed goatgrass	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1	1	
knotweed, common	Present		1	1,5	1,5	1,5	1						
	Treated		1	1,5	1,5	1,5	1			1			
kochia	Present				1,3	1,3	1,3	1,3	3				
	Treated			1,3	1,3	1,3	1,3	1			3		
lambsquarter	Present			1	1,5	1,3,5	1,3,5	1,3,5					
	Treated		1	1	1,5	1,3,5	1,3,5	1,3,5					

Seasonal Pest Occurrence by Regions - Chickpeas, cont.													
Weeds, cont.		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
marshelder	Present					3	3	3					
	Treated					3	3	3					
mayweed chamomile (dog fennel)	Present	5	1,5	1,5	1	1	1	1			5	5	5
	Treated	5	1,5	1,5	1	1	1	1		1	1,5	1,5	5
mustard, tall	Present	5	5	5							5	5	5
	Treated	5	5	5							5	5	5
nightshade, black	Present				1,5	1,3,5	1,3,5	1,3,5					
	Treated			1	1,5	1,3,5	1,3,5	1,3,5					
nightshade, hairy	Present				1,5	1,3,5	1,3,5	1,3,5					
	Treated			1	1,5	1,3,5	1,3,5	1,3,5					
oat, volunteer	Present	1,5	1,5	1,5	1,3	1,3	1			1	1,5	1,5	1,5
	Treated	5	1,5	1,3,5	1,3	1,3	1,3			1,3	1,3,5	1,5	5
oat, wild	Present	1,5	1,5	1,5	1,3	1,3	1,3			1	1,5	1,5	1,5
	Treated	5	5	1,3,5	1,3	1,3	1,3			1,3	1,3,5	1,5	1,5
pennycress, field	Present	1	1	1	1,3	1,3					1	1	1
	Treated			1	1,3	1,3							
pigweed, prostrate	Present				1	1	1	1					
	Treated				1	1	1	1					
pigweed, redroot	Present				1,5	1,3,5	1,3,5	1,3,5					
	Treated				1,5	1,3,5	1,3,5	1,5					
prickly lettuce	Present	1,5	1,5	1,5	1,3,5	1,3	1,3	1,3	1,3	3	1,5	1,5	1,5
	Treated	5	1,5	1,3,5	1,3,	1,3	1	1		1,3	1,3,5	1,5	5
purslane, common	Present				1,5	1,5	1,5	1,5					
	Treated			1	1,5	1,5	1,5	1,5					
quackgrass	Present	1	1	1	1	1,3	1,3	1,3	1,3	1	1	1	1
	Treated			1	1	3	3				1	1	
redstem filaree	Present	5	1,5	1,5	1						5	5	5
	Treated	5	5	1,5	1						5	5	5
Russian thistle	Present			5	1,3,5	1,3,5	1,3,5	1,3,5	1,3	1	1		
	Treated			1,3,5	1,3,5	1,3,5	1,5	1,5	1,3	1	1,3		
shepherdspurse	Present	1,5	1,5	1,5	1	1					1,5	1,5	1,5
	Treated	5	1,5	1,5	1	1				1	1,5	5	5
smartweed	Present		5	5	5	5							
	Treated		5	5	5	5							
sowthistle	Present	1,5	1,5	1,5	1,5	1	1	1	1	1	5	1,5	1,5
	Treated	5	1,5	1,5	1,5	1	1	1	1		1,5	1,5	5
volunteer canola	Present		1	1	1,3	1,3	1,3						
	Treated		1	1	1,3	1,3	1,3						
wheat, volunteer	Present	1,5	1,5	1,3,5	1,3	1,3	1,3	3	3	3,5	1,3,5	1,3,5	1,3,5
	Treated	5	5	1,3,5	1,3	1,3	1,3			3,5	3,5	3,5	5
wild buckwheat	Present				1,3	1,3	1,3	1,3					
	Treated		1	1,3	1,3	1,3	1,3				3		
wild mustard	Present	1,5	1,5	1,5	1,3	1,3	3	3		3	1,3,5	1,3,5	1,5
	Treated	5	1,5	1,5	1,3	1,3	1,3			1,3	1,3,5	1,3,5	5
wild radish	Present	5	5	1,5	1	1	1				5	5	5
	Treated	5	1,5	1,5	1	1	1				5	5	5
wild sunflower	Present			5	1,3,5	1,3,5	1,3,5	1,3	1	1	1		
	Treated				1,3	1,3	1,3	1					

Seasonal Pest Occurrence by Regions - Chickpeas, cont.													
Diseases		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Ascochyta rabiei	Present			5	5	3,5	3	3	3	3			
	Treated			5	3,5	3,5	3	3	3	3			
Botrytis spp.	Present						3	3	3				
	Treated						3	3	3				
Fusarium spp.	Present		5	5	5	3,5	3	3					
	Treated				3	3							
Pythium spp.	Present	5	5	5	3,5	3					5	5	5
	Treated	5	5	5	3,5	3					5	5	5
Rhizoctonia spp.	Present					3	3	3					
	Treated				3	3							
root complex	Present				3	3	3	3	3				
	Treated				3	3							
Sclerotinia spp.	Present		5	5	5	3,5	3,5	3	3				
	Treated				3	3	3	3					
Insects		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
alfalfa loopers	Present						1	1	1				
	Treated						1	1	1				
aphid, cowpea (*Aphis craccivora*)	Present						1	1	1				
	Treated						1	1	1				
aphid, pea (*Acyrthosiphum pisum* (Harris))	Present					1	1	1					
	Treated					1	1	1					
armyworms	Present				5	5	5						
	Treated				5	5	5						
cutworm, army	Present				3	3	3	3	3	3	3		
	Treated												
lepidoptera larvae	Present						1	1	1				
	Treated						1	1	1				
Lygus bug (*L. hespeus & L. elisus*)	Present					1	1	1					
	Treated					1	1	1					

Seasonal Pest Occurrence by Regions - Dry Peas													
Weeds		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
barley, volunteer	Present		1	1	1,3,4	1,3,4	1,3,4						
	Treated			1	1	1,3,4	1,3,4	3,4					
barnyardgrass	Present				1	1,3,4	1,3,4	3,4					
	Treated			1	1	1,3,4	1,3,4	3,4					
Canada thistle	Present	1	1	1	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1	1
	Treated				3,4	3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1	
chickweed, common	Present		1	1	1	1							
	Treated			1	1	1							
corn, volunteer	Present					3,4	3,4						
	Treated					3,4	3,4						
cornflower	Present				1	1	1	1					
	Treated				1	1	1	1					
cow cockle	Present		1	1	1	1							
	Treated				1	1							
dandelion	Present		1	1		3,4	3,4	3,4	3,4	3,4	3,4		
	Treated		1	1		3,4	3,4			3,4	3,4		
downy brome	Present	1	1	1,3,4	1,3,4	1,3,4	1			3,4	1,3,4	1	1
	Treated		1	1	1,3,4	1,3,4				3,4	1,3,4	1	
field bindweed	Present	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
	Treated				3,4	3,4	3,4		3,4	3,4	3,4		
flixweed	Present		1	1	1	1	1						
	Treated		1	1	1	1	1						
foxtail barley	Present				3,4	3,4	3,4	3,4	3,4	3,4	3,4		
	Treated				3,4	3,4	3,4			3,4	3,4		
foxtail, green	Present				1,3,4	1,3,4	1,3,4	3,4					
	Treated			1	1	1,3,4	1,3,4						
foxtail, yellow	Present				1,3,4	1,3,4	1,3,4	3,4					
	Treated			1	1	1,3,4	1,3,4						
Gallium spp.	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1		
gromwell, corn	Present		1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1		
henbit	Present	1	1	1	1	1					1	1	1
	Treated		1	1	1	1				1	1		
horseweed/ Canada fleabane	Present	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	3,4	3,4	3,4	3,4	1,3,4	1,3,4	1,3,4
	Treated			1	1,3,4	1,3,4				3,4	3,4		
Italian ryegrass	Present	1	1	1	1	1	1	1			1	1	1
	Treated			1	1	1	1			1	1	1	
jointed goatgrass	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1	1	
knotweed, common	Present		1	1	1	1	1						
	Treated		1	1	1	1	1			1			
kochia	Present				1,3,4	1,3,4	1,3,4	1,3,4	3,4				
	Treated			1,3,4	1,3,4	1,3,4	1,3,4	1			3,4		
lambsquarter	Present			1	1	1,3,4	1,3,4	1,3,4					
	Treated		1	1	1	1,3,4	1,3,4	1,3,4					
marshelder	Present					3,4	3,4	3,4					
	Treated					3,4	3,4	3,4					

Seasonal Pest Occurrence by Regions - Dry Peas, cont.													
Weeds, cont.		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
mayweed chamomile (dog fennel)	Present		1	1	1	1	1	1					
	Treated		1	1	1	1	1	1		1	1	1	
nightshade, black	Present				1	1,3,4	1,3,4	1,3,4					
	Treated			1	1	1,3,4	1,3,4	1,3,4					
nightshade, hairy	Present				1	1,3,4	1,3,4	1,3,4					
	Treated			1	1	1,3,4	1,3,4	1,3,4					
oat, volunteer	Present	1	1	1	1,3,4	1,3,4	1			1	1	1	1
	Treated		1	1,3,4	1,3,4	1,3,4	1,3,4			1,3,4	1,3,4	1	
oat, wild	Present	1	1	1	1,3,4	1,3,4	1,3,4			1	1	1	1
	Treated			1,3,4	1,3,4	1,3,4	1,3,4			1,3,4	1,3,4	1	1
pennycress, field	Present	1	1	1	1,3,4	1,3,4					1	1	1
	Treated			1	1,3,4	1,3,4							
pigweed, prostrate	Present				1	1	1	1					
	Treated				1	1	1	1					
pigweed, redroot	Present				1	1,3,4	1,3,4	1,3,4					
	Treated				1	1,3,4	1,3,4	1					
prickly lettuce	Present	1	1	1	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	3,4	1	1	1
	Treated		1	1,3,4	1,3,4	1,3,4	1	1		1,3,4	1,3,4	1	
purslane, common	Present				1	1	1	1					
	Treated			1	1	1	1	1					
quackgrass	Present	1	1	1	1	1,3,4	1,3,4	1,3,4	1,3,4	1	1	1	1
	Treated			1	1	3,4	3,4				1	1	
redstem filaree	Present		1	1	1								
	Treated			1	1								
Russian thistle	Present				1,3,4	1,3,4	1,3,4	1,3,4	1,3,4	1	1		
	Treated			1,3,4	1,3,4	1,3,4	1	1	1,3,4	1	1,3,4		
shepherdspurse	Present	1	1	1	1	1					1	1	1
	Treated		1	1	1	1				1	1		
annual sowthistle	Present	1	1	1	1	1	1	1	1	1		1	1
	Treated		1	1	1	1	1	1	1		1	1	
volunteer canola	Present		1	1	1,3,4	1,3,4	1,3,4						
	Treated		1	1	1,3,4	1,3,4	1,3,4						
wheat, volunteer	Present	1	1	1,3,4	1,3,4	1,3,4	1,3,4	3,4	3,4	3,4	1,3,4	1,3,4	1,3,4
	Treated			1,3,4	1,3,4	1,3,4	1,3,4			3,4	3,4	3,4	
wild buckwheat	Present				1,3,4	1,3,4	1,3,4	1,3,4					
	Treated			1,3,4	1,3,4	1,3,4	1,3,4	1					
wild mustard	Present	1	1	1	1,3,4	1,3,4	3,4	3,4		3,4	1,3,4	1,3,4	1
	Treated		1	1	1,3,4	1,3,4	1,3,4			1,3,4	1,3,4	1,3,4	
wild radish	Present			1	1	1	1						
	Treated		1	1	1	1	1						
wild sunflower	Present				1,3,4	1,3,4	1,3,4	1,3,4	1	1	1		
	Treated				1,3,4	1,3,4	1,3,4	1					
yellow rocket	Present												
	Treated												

Seasonal Pest Occurrence by Regions - Dry Peas, cont.													
Diseases		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Aphanomyces euteiches	Present					1	1	1	1				
	Treated												
Ascochyta blight (Mycosphaerella pinodes)	Present	1	1	1	1	1	1	1					
	Treated					1	1	1					
bacterial blight	Present					3,4	3,4	3,4	3,4	3,4			
	Treated												
bean/pea leafroll virus	Present					1,3,4	1,3,4	1,3,4					
	Treated					1	1	1					
downy mildew	Present					1	1	1					
	Treated												
Fusarium seedling blight	Present			1	1	1							
	Treated			1	1								
Fusarium solani f. sp. pisi	Present			1	1	1,3,4	1,3,4	1,3,4					
	Treated			1	1,3,4	3,4							
Fusarium wilt (*Fusarium oxysporum)*	Present					1	1	1					
	Treated												
Mycosphaerella spp.	Present				3,4	3,4	3,4	3,4	3,4				
	Treated						3,4	3,4					
nematodes	Present					3,4	3,4	3,4	3,4	3,4			
	Treated												
pea enation mosaic virus	Present					1	1	1					
	Treated					1	1	1					
Phoma medicagonis	Present	1	1	1	1	1	1	1					
	Treated												
powdery mildew (*Erisiphe pisi)*	Present					1	1,3,4	1,3,4	3,4	3,4			
	Treated					1	1,3,4	1,3,4					
Pythium spp.	Present			1	1,3,4	1,3,4							
	Treated			1	1,3,4	3,4							
Rhizoctonia spp.	Present			1	1	1,3,4	3,4	3,4					
	Treated			1	1,3,4	3,4							
root complex	Present				3,4	3,4	3,4	3,4	3,4				
	Treated				3,4	3,4							
Sclerotinia stem rot	Present					1	1,3,4	1,3,4	1,3,4				
	Treated				3,4	3,4	1,3,4	1,3,4					
Insects		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
alfalfa loopers	Present						1,3,4	3,41,	1,3,4	3,4	3,4		
	Treated						1	1	1				
aphid, cowpea (*Aphis craccivora*)	Present						1,3,4	1,3,4	1,3,4	3,4	3,4		
	Treated						1	1,3,4	1,3,4				
aphid, pea (*Acyrthosiphum pisum* (Harris))	Present					1	1,3,4	1,3,4	3,4	3,4	3,4		
	Treated					1	1	1,3,4	3,4				
cutworm, army	Present				3,4	3,4	3,4	3,4	3,4	3,4	3,4		
	Treated												
cutworm, pale western	Present						1,3,4	1,3,4	1,3,4				
	Treated						1,3,4	1	1				

Seasonal Pest Occurrence by Regions - Dry Peas, cont.													
Insects, cont.		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
cutworm, redbacked	Present						1,3,4	1,3,4	1,3,4				
	Treated						3,4						
grasshoppers	Present					1,3,4	1,3,4	1,	3,4	3,4	3,4		
	Treated					1	1,3,4	1,3,4	3,4				
leafhoppers	Present				1	1,3,4	1,3,4	1,3,4	3,4	3,4		3,4	
	Treated												
lepidoptera larvae	Present					3,4	1,3,4	1,3,4	1,3,4				
	Treated												
Lygus bug (*L. hespeus* & *L. elisus*)	Present					1,3,4	1,3,4	1,3,4	3,4	3,4	3,4		
	Treated					1	1,3,4	1,3,4					
pea leaf weevil (*Sitona lineata*)	Present			1	1	1							
	Treated			1	1	1							
pea moth	Present					1	1	1					
	Treated					1	1	1					
pea weevil (*Bruchus pisorum)*	Present					1	1	1					
	Treated					1	1	1					
thrips	Present			1	1	1	1	1	1				
	Treated					1	1	1					
wireworms (*Limonius* spp.)	Present	1	1	1	1,3,4	1,3,4	1,3,4	1	1	1	1	1	1
	Treated			1	1	1							

Seasonal Pest Occurrence by Regions- Lentils													
Weeds		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
barley, volunteer	Present		1	1	1,3	1,3	1,3						
	Treated					3	3	3					
barnyardgrass	Present				1	1,3	1,3	3					
	Treated			1	1	1,3	1,3	3					
Canada thistle	Present	1	1	1	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1	1
	Treated				3	3	1,3	1,3	1,3	1,3	1,3	1	
chickweed, common	Present		1	1	1	1							
	Treated			1	1	1							
corn, volunteer	Present					3	3						
	Treated					3	3						
cornflower	Present				1	1	1	1					
	Treated				1	1	1	1					
cow cockle	Present		1	1	1	1							
	Treated				1	1							
dandelion	Present		1	1		3	3	3	3	3	3		
	Treated		1	1		3	3			3	3		
downy brome	Present	1	1	1,3	1,3	1,3	1			3	1,3	1	1
	Treated		1	1	1,3,	1,3				3	1,3	1	
field bindweed	Present	3	3	3	3	3	3	3	3	3	3	3	3
	Treated				3	3	3		3	3	3		
flixweed	Present		1	1	1	1	1						
	Treated		1	1	1	1	1						
foxtail barley	Present				3	3	3	3	3	3	3		
	Treated				3	3	3			3	3		
foxtail, green	Present				1,3	1,3	1,3	3					
	Treated			1	1	1,3	1,3						
foxtail, yellow	Present				1,3	1,3	1,3	3					
	Treated			1	1	1,3	1,3						
Gallium spp.	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1		
gromwell, corn	Present		1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1		
henbit	Present	1	1	1	1	1					1	1	1
	Treated		1	1	1	1				1	1		
horseweed/ Canada fleabane	Present	1,3	1,3	1,3	1,3	1,3	3	3	3	3	1,3	1,3	1,3
	Treated			1	1,3	1,3				3	3		
Italian ryegrass	Present	1	1	1	1	1	1	1			1	1	1
	Treated			1	1	1	1			1	1	1	
jointed goatgrass	Present	1	1	1	1	1	1				1	1	1
	Treated		1	1	1	1	1			1	1	1	
knotweed, common	Present		1	1	1	1	1						
	Treated		1	1	1	1	1			1			
kochia	Present				1,3	1,3	1,3	1,3	3				
	Treated			1,3	1,3	1,3	1,3	1			3		
lambsquarter	Present			1	1	1,3	1,3	1,3					
	Treated		1	1	1	1,3	1,3	1,3					
marshelder	Present					3	3	3					
	Treated					3	3	3					

Seasonal Pest Occurrence by Regions- Lentils, cont.													
Weeds, cont.		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
mayweed chamomile (dog fennel)	Present		1	1	1	1	1	1					
	Treated		1	1	1	1	1	1		1	1	1	
nightshade, black	Present				1	1,3	1,3	1,3					
	Treated			1	1	1,3	1,3	1,3					
nightshade, hairy	Present				1	1,3	1,3	1,3					
	Treated			1	1	1,3	1,3	1,3					
oat, volunteer	Present	1	1	1	1,3	1,3	1			1	1	1	1
	Treated		1	1,3	1,3	1,3	1,3			1,3	1,3	1	1
oat, wild	Present	1	1	1	1,3	1,3	1,3			1	1	1	1
	Treated			1,3	1,3	1,3	1,3			1,3	1,3	1	1
pennycress, field	Present	1	1	1	1,3	1,3					1	1	1
	Treated			1	1,3	1,3							
pigweed, prostrate	Present				1	1	1	1					
	Treated				1	1	1	1					
pigweed, redroot	Present				1	1,3	1,3	1,3					
	Treated				1	1,3	1,3	1					
prickly lettuce	Present	1	1	1	1,3	1,3	1,3	1,3	1,3	3	1	1	1
	Treated		1	1,3	1,3	1,3	1	1		1,3	1,3	1	
purslane, common	Present				1	1	1	1					
	Treated			1	1	1	1	1					
quackgrass	Present	1	1	1	1	1,3	1,3	1,3	1,3	1	1	1	1
	Treated			1	1	3	3				1	1	
redstem filaree	Present		1	1	1								
	Treated			1	1								
Russian thistle	Present				1,3	1,3	1,3	1,3	1,3	1	1		
	Treated			1,3	1,3	1,3	1	1	1,3	1	1,3		
sheperdspurse	Present	1	1	1	1	1					1	1	1
	Treated		1	1	1	1				1	1		
annual sowthistle	Present	1	1	1	1	1	1	1	1	1		1	1
	Treated		1	1	1	1	1	1	1		1	1	
volunteer canola	Present		1	1	1,3	1,3	1,3						
	Treated		1	1	1,3	1,3	1,3						
wheat, volunteer	Present	1	1	1,3	1,3	1,3	1,3	3	3	3	1,3	1,3	1,3
	Treated			1,3	1,3	1,3	1,3			3	3	3	
wild buckwheat	Present				1,3	1,3	1,3	1,3					
	Treated			1,3	1,3	1,3	1,3	1			3		
wild mustard	Present	1	1	1	1,3	1,3	3	3		3	1,3	1,3	1
	Treated		1	1	1,3	1,3	1,3			1,3	1,3	1,3	
wild radish	Present			1	1	1	1						
	Treated		1	1	1	1	1						
wild sunflower	Present				1,3	1,3	1,3	1,3	1	1	1		
	Treated				1,3	1,3	1,3	1					

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Seasonal Pest Occurrence by Regions- Lentils, cont.													
Diseases		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Ascochyta lentis	Present						3	3	3	3			
	Treated				3	3	3	3					
Botrytis spp.	Present						3	3					
	Treated						3	3					
Colletotrichum truncatum	Present						3	3	3				
	Treated						3	3					
Fusarium spp.	Present					3	3	3					
	Treated				3	3							
Pythium spp.	Present				3	3							
	Treated				3	3							
Rhizoctonia spp.	Present					3	3	3					
	Treated				3	3							
root complex	Present				3	3	3	3	3				
	Treated				3	3							
Sclerotinia spp.	Present						3	3	3				
	Treated						3	3					
Insects		**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
alfalfa loopers	Present						1	1	1				
	Treated						1	1	1				
aphid, cowpea (*Aphis craccivora*)	Present						1	1	1				
	Treated						1	1	1				
aphid, pea (*Acyrthosiphum pisum* (Harris))	Present					1	1	1					
	Treated					1	1	1					
cutworm, army	Present				3	3	3	3	3	3	3		
	Treated												
cutworm, pale western	Present						1	1	1				
	Treated						1	1	1				
cutworm, redbacked	Present						1	1	1				
	Treated						1	1	1				
grasshoppers	Present					1	1	1					
	Treated					1	1	1					
leafhoppers	Present				1	1	1	1					
	Treated												
lepidoptera larvae	Present						1	1	1				
	Treated						1	1	1				
Lygus bug (*L. hespeus & L. elisus*)	Present					1	1	1					
	Treated					1	1	1					
pea leaf weevil (*Sitona lineata*)	Present			1	1	1							
	Treated			1	1	1							
pea moth	Present					1	1	1					
	Treated					1	1	1					
pea weevil (*Bruchus pisorum)*	Present					1	1	1					
	Treated					1	1	1					
thrips	Present			1	1	1	1	1	1				
	Treated					1	1	1					
wireworms (*Limonius* spp.)	Present	1	1	1	1	1	1	1	1	1	1	1	1
	Treated			1	1	1							

Toxicity Ratings on Pollinators and Beneficials

AB=Alakai Bees, **HB**=Honeybees, **LCB**=Leafcutting Bees, **BEB**=Big-eyed bugs, **CB**=Carabid beetles (Carabidae family) and Rove Beetles (Staphylinidae family), **DB**=Damsel bug, **LW**=Lacewings (*Chrysopa* spp.), **LB**=Lady beetles (*Coccinella septempunctata*, *Harmonia axyridis*, *Hippodamia convergens*), **MPB**=Minute pirate bugs (*Orius* spp.), **PBT**=Predatory Beetles (*Stethorus* spp.), **PM**=Predatory mites (Acari:Phytoseiidae), **PN**=Predatory nematodes, **PW**=Parasitic wasps (Braconidae, Chalcidae, Ichneumonidae and Mymaridae families), **S**=Spiders (*Erigone aletris*, *E. blaesa*, and *E. dentosa*), **SF**=Syrphid flies, **TF**=Tachinid flies, and **TSS**=Two-spotted stinkbug.

Rating Scale: E=Excellent survivability (non-toxic), G=Good survivability (slightly toxic), F=Fair survivability (moderately toxic), P=Poor survivability (highly toxic), ND=No data, Blank=dDo not know, ?=Data vary appreciably between regions or circumstances.

Rating Scale (Pollinators only): 0 = no data or experience available, 1 = do not apply to blooming plants (residual greater than 1 day), 2 = apply in evening after bees have stopped foraging (residual 4-12 hours), 3 = apply in late evening until early morning (residual 2-4 hours), 4 = apply at any time with reasonable safety to bees (residual negligible)

	Pollinators			Beneficials													
	AB	HB	LCB	BEB	CB	DB	LW	LB	MPB	PBT	PM	PN	PW	S	SF	TF	TSS
Registered Insecticides/Miticides																	
Bacillus thuringiensis	4	4	4	E		E	E	E	E		E	E	E	E	E	E	
bifenthrin (Capture)	1	1	1	P-F		P-F	P-F	P-F	P-F		P-F		P	P	P	P	
carbaryl (Sevin)	1	1	1	F-G		F-G	F-G	P-G	F-G		P	ND	F	F	F	F	
chlorpyrifos (Lorsban)	1	1	1	P-F		P-F	P-G	P-F	P-F	F	P-F	P	P	P	P	P	
cyfluthrin (Baythroid)				F?		F?			P?					P?			
cypermethrin (Ammo)		E		F		F	F	F	F		F	F	F	P	F	F	
dimethoate (Dimethoate)	1	1	1	P-F		P-F	P-F	P-F	P-F		P						
disulfoton (Disyston)				F		G-F			P-F					G			
endosulfan (Endosulfan, Phaser)	3	1	2	P-F	F	?	?	?	F-E		P-F, G		F	P-F	F	F	
esfenvalerate (Asana)		E		F		P-F	F	P	P		P	ND	P	P	P	P	
imidacloprid (Admire) (soil-applied) *		F		F-G		F-G	F-G	?	?	P	?	ND	G	G-E	G	G	
imidacloprid (Provado) (foliar)		F		F		F	F	P-F	P-F	P	P-F	ND	F	F	F	F	F
lambda-cyhalothrin (Warrior)	1	1	1	P-F		P-F	P-F	P-F	P-F		P-F	ND	P-F	P	P-F	P-F	
malathion (Malathion)	1	1	1	F		F	F	P	F		P	F	F	P-F	P	F	
methomyl (Lannate)	1	1	1	P-F		P-F	P	P	P		P	P	P	F	P	P	
methyl parathion (Penncap-M, Methyl Parathion)	1	1	1	P		P	P	P	P		P	P	P	P	P	P	P
phosmet (Imidan)	1	1	2				G	P			E						
spinosad (Entrust, SpinTor, Success, Tracer)		F		F		F	F-G	F	F		F	ND	F	F	F	F	
sulfur (Sulfur)	4	4	4	G		G	F-G	F-G	G/P		?	ND	F	ND	F	F	
thiamethoxam (Actara) (foliar)		F		F-G		F-G	F-G	F-G	F-G		F-G	F-G	F-G	F-G	F-G	F-G	

Toxicity Ratings on Pollinators and Beneficials

	Pollinators			Beneficials													
	AB	HB	LCB	BEB	CB	DB	LW	LB	MPB	PBT	PM	PN	PW	S	SF	TF	TSS
Registered Insecticides/Miticides, cont.																	
thiamethoxam (Platinum) (soil-applied) †		F-G		G		G	G	G	G		G		G	G	G		
zeta-cypermethrin (Mustang)	1	1	1	P-F		P-F	P-F	P-F	P-F		P-F	ND	P-F	F	P-F	P-F	
Seed Treatments																	
captan (Captan 400)		E		E	E	E	E	E	E		E		E	E	E	E	
chlorpyrifos (Lorsban)				E	E	E	E	E	E		E		E	E	E	E	
imidacloprid (Gaucho)		E		E	E	E	E	E	E		E		E	E	E	E	
thiamethoxam (Cruiser)		E		E	E	E	E	E	E		E		E	E	E	E	
Biocontrols																	
Beetles (Rove and Ground)																	
Nosema locustae	4	4	4														
Parasitic nematodes																	
Parasitoid wasps																	
Predatory flies																	
Fungicides																	
azoxystrobin (Amistar, Quadris)											E						
captan (Captan 400)				ND		ND	G	F	G		G	ND	G	ND	F	G	
mefanoxam (Ridomil Gold)				ND		ND	ND	ND	ND		G	P	ND	ND	ND	ND	
myclobutanil (Laredo, Rally)								E		E	E						
sulfur (various)				G		G	F-G	F-G	?	E	?	ND	F-G	ND	F	F	
Herbicides																	
diuron (Karmex)				ND		E	ND	F	E		F	ND	G	ND	ND	ND	
glufosinate (Rely)		F		F		F	F	F	F		F	F	F	F	F	F	
glyphosate (various)				F		ND	ND	ND	ND		P	ND	G	ND	ND	ND	
paraquat (Gramoxone)				ND		ND	ND	ND	ND		P	ND	ND	ND	ND	ND	
simazine (Simazine, Princep)				ND		ND	ND	F	ND		G	ND	F	ND	ND	ND	
terbacil (Sinbar)				ND		ND	ND	ND	ND		F	ND	ND	ND	ND	ND	
trifluralin (various)				ND		ND	ND	ND	ND		ND	ND	P-F	ND	ND	ND	

Toxicity Ratings on Pollinators and Beneficials

	Pollinators			Beneficials													
	AB	**HB**	**LCB**	**BEB**	**CB**	**DB**	**LW**	**LB**	**MPB**	**PBT**	**PM**	**PN**	**PW**	**S**	**SF**	**TF**	**TSS**
Fumigants																	
1,3-dichloropropene (Telone II) (fumigant) *												P					
methyl bromide *												P					
methyl bromide + chloropicrin *												P					
Cultural/Non-Chemical Controls																	
Adjacent Area Management													P	P	P	P	
	May be hazardous if habitat removed.																
Avoid Excessive Nitrogen	Neutral.																
Baited Traps	Neutral.																
Crop Rotation	Variable ecological impacts on polyphagous natural enemies.																
Enhancing Habitat for Beneficials	Beneficial: habitat, shelter and alternative prey.																
Equipment Sanitation	Neutral.																
Flaming	P	P	P	P		P	P	P	P		P	P	P	P	P	P	P
	Temporary hazard to soil surface and foliage-borne fauna.																
Hand Hoeing		P		P		P	P	P	P		P		P	E	P	P	
Irrigation Scheduling	Neutral.																
Irrigation Amount	Neutral.																
Mowing	Short-term disruption to foliage dwellers.																
Mulching	Beneficial: habitat, shelter and alternative prey.																
New Over Old Training	Neutral.																
Plant Resistant Varieties	Neutral.																
Row Spacing	Neutral.																
Sanitation	May be hazardous if habitat removed.																
Solarize	May be hazardous to soil dwellers.																
Tillage	Short term disruption to soil dwellers																
Weed Control around Field Borders	May impact habitat/alternative prey for some species.																
Weed Management	May impact habitat/alternative prey for some species.																

* Not toxic to foliage-borne beneficials. † Low probability of harm to beneficials.

Trade Name	Ingredient
Achieve	tralkoxydim
Actara 25WP	thiamethoxam (floral spray)
Affirm	tralkoxydim
Aim	carfentrazone-ethyl
Allegiance FL	metalaxyl
Ally	metsulfuron methyl
Amber	triasulfuron
Ambush	permethrin
Amitrol	amitrole
Apron FL	metalaxyl
Apron XL	mefenoxam
Asana	esfenvalerate
Assert	imazamethabenz-methyl
Assure II	quizalofop-P-ethyl
Attain	fluroxypyr
Avadex BW	triallate
Avenge	difenzoquat methyl sulfate
Banvel	dimethylamine salt of dicamba
Basagran	bentazon
Baythroid	cyfluthrin
Bonanza	trifluralin
Bravo 500	chlorothalonil
Bronate	bromoxynil octanoate + MCPA, 2-ethyl hexyl ester
Buctril	octanoic acid ester of bromoxynil
Caliber	2,4-DB
Canvas	thifensulfuron methyl + tribenuron methyl + metsulfuron methyl
Caparol 4L	prometryn
Captan FL, Captan 400	captan
Capture 2E	bifenthrin
Chiptox	MCPA, sodium salt
Clarity	diglycolamine salt of dicamba
Cobutox	2,4-DB
Curtail	2,4-D triisopropa-nolamine + clopyralid
Cygon	dimethoate
Diquat	diquat
Di-Syston	disulfoton
Discover	clodinafop-propargyl
Dithane DG	mancozeb
Diuron	diuron

Trade Name	Ingredient
Dual (II) Magnum	s-metolachlor
Edge	ethalfluralin
Embutox	2,4-DB
Endosulfan	endosulfan
Everest	flucarbazone-sodium
Express	tribenuron methyl
Far-Go	triallate
Finesse	metsulfuron methyl + chlorsulfuron
Frontier 6EC	dimethenamid
Fusion	fluazifop-P-butyl + fenoxaprop
Gaucho	imidacloprid
Glean	chlorsulfuron
Goal	oxyfluorfen
Gramoxone Extra	paraquat dichloride
Harmony Extra	thifensulfuron-methyl + tribenuron methyl
Harmony GT	thifensulfuron methyl
Headline	pyraclostrobin
Helix	thiamethoxam (seed treatment)
Hoelon	diclofop-methyl
Horizon	clodinafop-propargyl
Imidan	phosmet
Kerb	pronamide
Kumulus DF	sulfur
Lannate	methomyl
Legend	cyfluthrin+ imidacloprid
Lexone DF	metribuzin
Liberty	glufosinate-ammonium
Lindane	lindane
Lorsban	chlorpyrifos
LSP	thiabendazole
Malathion	malathion
Maverick	sulfosulfuron
Maxim	fludioxonil
MCPA	MCPA
Mecoprop	MCCP
Mertect	thiabendazole
Mustang	zeta-cypermethrin
Muster	ethametsulfuron

Trade Name	Ingredient
Nova	myclobutanil
Outlook	dimethenamid-P
Paramount	quinclorac
Paraquat	paraquat
Parathion	parathion
PCNB	PCNB
Peak	prosulfuron
Pirimor	pirimicarb
Poast	sethoxydim
Pounce	permethrin
Proline	prothioconazole
Prometryne 4L	prometryn
Provado	imidacloprid
Prowl	pendimethalin
Puma	fenoxaprop-p
Pursuit	imazethapyr
Quadris	azoxystrobin
Raptor	imazamox
Rival	trifluralin
Roundup Ultra	glyphosate
Select	clethodim
Sencor	metribuzin
Sevin	carbaryl
Simazine	simazine
Sonalan	ethalfluralin
Spartan	sulfentrazone
Starane	fluroxypyr 1-methylheptyl ester
Stinger	clopyralid, mono-ethanolamine salt
Success	spinosad
Tachigaren	hymexazol
Telone II	dichloropropene
Thistrol	MCPB
Thiram 75WP	thiram
Tordon	picloram, potassium salt
Tough	pyridate
Treflan	trifluralin
Venture	fluazifop-P-butyl
Warrior	lambda-cyhalothrin

Pesticide List, Sorted by Ingredient

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