Pest Management Strategic Plan
for
Western U.S.
Alfalfa and Clover Seed Production

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Lead Authors: Ronda Hirnyck, Lisa Downey
Editor: Sally O'Neal Coates

Contact Person:
Ronda Hirnyck, Idaho Pesticide Program Coordinator
(208) 364-4046
rhirnyck@uidaho.edu

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Work Group

Work Group Members in Attendance

California
Shannon Mueller, Farm Adviser, Fresno County, University of California

Idaho
Ronda Hirnyck, Pesticide Program Coordinator, University of Idaho, Boise, ID
Lisa Downey, PMSP Research Assistant, University of Idaho, Boise, ID
Jim Barbour, Research and Extension Entomologist, University of Idaho, Parma, ID
Jerry Neufeld, Agriculture Extension Educator, University of Idaho, Caldwell, ID
Mir-M Seyedbagheri, Agriculture Extension Educator, University of Idaho, Mountain Home, ID
Saad Hafez, Nematologist, University of Idaho, Parma, ID
Don Miller, Alfalfa Breeder, ABI Alfalfa, Nampa, ID
Ron Bitner, Consultant, Caldwell, ID
Jim Briggs, Alfalfa Seed Grower, Marsing, ID
Stuart Emry, Alfalfa Seed Grower, Homedale, ID
Lynn Nichols, Seed Dealer, Dairyland Seed, Homedale, ID
Mike Talkington, Sunseeds, Parma, ID

Montana
Will Lanier, Pest Management Educator, Montana State University, Bozeman, MT

Nevada
Dan Hetrick, Alfalfa Seed Grower, Orovada, Nevada

Oregon
Joe DeFrancesco, Western PMSP Coordinator, Oregon State University, Corvallis, OR
Corey Ransom, Weed Scientist, Oregon State University, Ontario, OR
Dave Anderson, Consultant, Woodburn, OR
Neil Allison, Clover Seed Grower, Adrian, OR

Utah
Jay Karren, Entomologist, Utah State University, Logan, UT

Washington
John Kugler, Extension Educator, Washington State University, Ephrata, WA
Tim Woodward, Extension Educator, Washington State University, Pasco, WA
Mike McCubbans, Consultant, Othello, WA
Dale Pomeroy, Alfalfa Seed Grower, Warden, WA

Work Group Members Not in Attendance

Montana
Sue Blodgett, Extension IPM Coordinator, Montana State University, Bozeman, MT

Nevada
Don Breazeale, Extension Educator, University of Nevada, Lovelock, NV

Utah
Stanford Young, Utah Crop Improvement Association, Utah State University, Logan, UT
Howard Deer, Pesticide Coordinator, Utah State University, Logan, UT
Jim Cane, Bee Biologist, Utah State University, Logan, UT

Washington
Ekaterini Riga, Nematologist, Washington State University, Prosser, WA

Wyoming
John Grover, Alfalfa Seed Grower
Alan Gray, Agronomist, Powel Research and Extension Center, University of Wyoming, Powell, WY

Workshop Observers
Linda Herbst, Assistant Director, Western IPM Center, University of California, Davis, CA
Gary McRae, EPA Region X, Boise, ID

SUMMARY OF THE MOST CRITICAL NEEDS IN WESTERN U.S. ALFALFA AND CLOVER SEED PEST MANAGEMENT

(Pest-specific and crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout document.)

Research Priorities

1. Develop new biological controls, new chemistries, and resistant alfalfa germplasm for lygus bug control.
2. Research the biology and ecology of natural enemies of lygus bug.
3. Develop regional lygus bug resistance monitoring programs.
4. Develop new pest management strategies for pollinator bee safety (esp. disease management strategies).
5. Update economic thresholds for insects and beneficials; standardize sampling techniques for insect levels.
6. Develop new, cost effective controls for noxious weeds (e.g., dodder, Canada thistle, white cockle, and other difficult-to-control weeds).
7. Develop growing degree-day models for major alfalfa seed pests.
8. Develop systemic aphicide for clover aphids.
9. Develop soil insecticide for crown/root borer in red clover (western Oregon).
10. Develop control measures for Sclerotinia in red clover (western Oregon).

Regulatory Priorities

1. Maintain current registrations of organophosphate insecticides.
2. Encourage state departments of agriculture to play a bigger role in regulating GMOs (i.e., control of pollen transfer and concerns with foreign markets).
3. Maintain a wide variety of chemical controls (including broad-spectrum and selective pesticides) for resistance management.
4. Enlist industry input to EPA when making decisions on pesticides in reference to ground and surface water quality.
5. Collaborate with all Western states to pursue new pesticide labels.

Education Priorities

1. Continue to provide field tours to improve regulators' understanding of production practices and to increase awareness of beneficial pollinator importance to the crop.
2. Educate public on the utility of pesticides and benefits of using chemicals vs. not using chemicals (i.e., risk education). This includes education at the school, university, EPA, and legislature levels.
3. Develop a regional pest management strategy focusing on resistance management, especially for lygus bug and aphids. Develop an educational program for resistance monitoring.

4. List alfalfa hay crop in the Best Management Practices handbook (i.e., NRCS conservation plan to encourage planting of alfalfa vs. corn or other traditional crops). Explain benefits of alfalfa over corn (i.e., less runoff, less erosion, less tillage, adding nitrogen to the soil, acts as a soil conditioner, classified as a carbon sink).
5. Educate general public on importance of pollinator bees.
6. Provide education on the delivery and utility of growing-degree-day models for insects and weeds.
7. Educate public and legislators on benefits of field burning and how they may outweigh the drawbacks (i.e., risk education).

INTRODUCTION

The Environmental Protection Agency (EPA) is now engaged in the process of re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA). The Agency is examining dietary, ecological, residential, and occupational risks posed by certain pesticides. EPA's regulatory focus on the organophosphate (OP), carbamate, and B2 carcinogen pesticides has created uncertainty as to the future availability of these products to growers. At some point, EPA may propose to modify or cancel some or all uses of these chemicals on alfalfa and clover seed. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling certain registrations for alfalfa and clover seed.

The Endangered Species Act (ESA) mandates that Federal agencies such as EPA consult with the National Oceanic and Atmospheric Administration (NOAA-Fisheries) if that agency takes an action that may affect threatened or endangered species. Lawsuits have been filed against EPA stating that they failed to complete this consultation process. The result of one of these lawsuits is that mandatory no-spray buffer zones have been imposed for certain pesticides in salmonid habitat in Washington, Oregon, and California. Other threatened and endangered species are located throughout alfalfa and clover seed growing regions and there are likely to be further no-spray buffer requirements, whether lawsuit-mandated or resulting from the consultation process. No one knows the impact of buffer strips on agro-ecosystems or the pest complex. Whether planted to crops or abandoned to weeds, untreated buffer strips have great potential to act as pest reservoirs. If pest control is not possible, growers may resort to cultivation to keep buffer zones free of weeds. Cultivation, especially near waterways, will lead to increased sediment loads in streams.

The total effects of ESA implementation and FQPA re-registration are yet to be determined. Clearly, however, new pest management strategies will be required in the alfalfa/clover seed industry.

In a proactive effort to identify pest management priorities and lay a foundation for future strategies, alfalfa and clover seed growers, industry representatives, crop consultants, and university specialists from California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming formed a work group and assembled the following document. Members of the group met for two days in February 2004, in Boise, Idaho, where they discussed the FQPA and possible pesticide regulatory actions and drafted a document containing critical needs, general conclusions activity timetables, and efficacy ratings of various management tools for specific pests. The resulting document was reviewed by the workgroup, including additional people who were not present at the meeting. The final result was this document, a comprehensive transition foundation addressing many pest-specific critical needs for the alfalfa seed and clover seed industries in the western United States.

The document begins with a region-by-region overview of alfalfa and clover seed production in the western states, followed by discussion of critical production aspects of these crops including the unique importance of pollinators, the basics of Integrated Pest

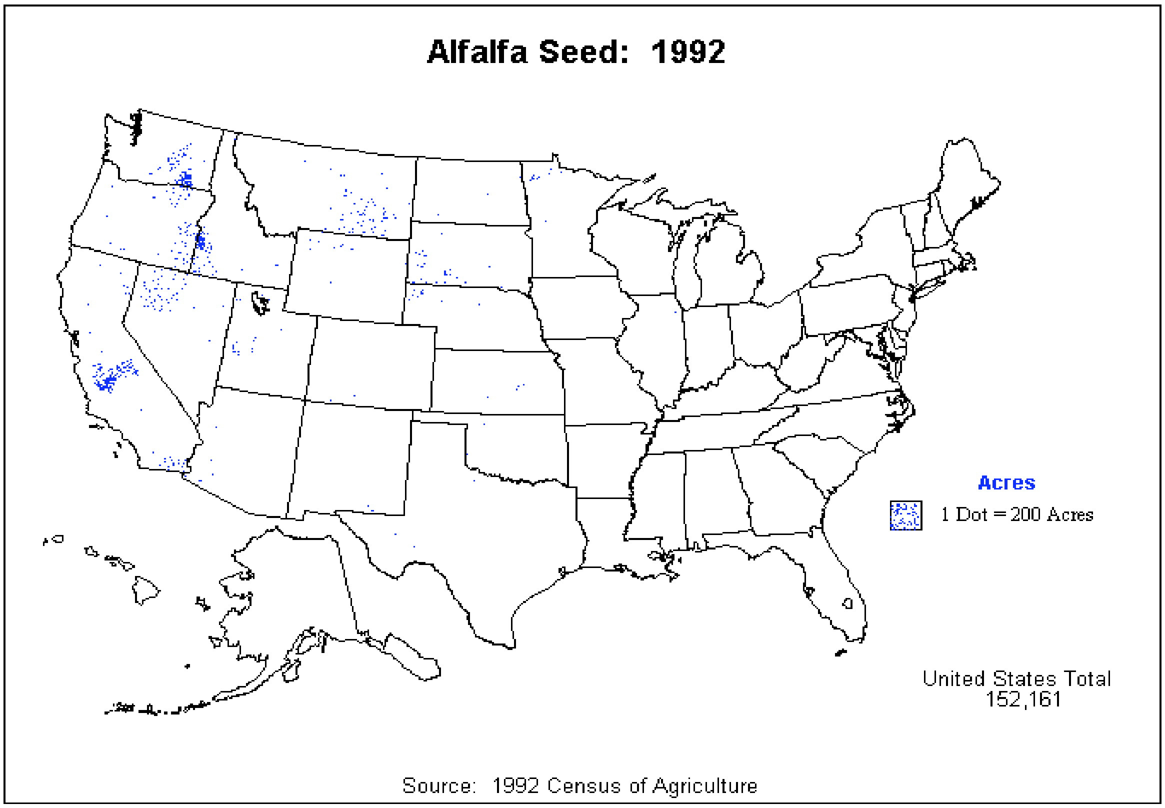
Management (IPM) in these seed crops, rotation and isolation of the crops, the crops' non-food status, and the role of genetically modified organisms (GMOs) in these crops. The remainder of the document is an analysis of pest pressures during the production of alfalfa seed and clover seed, organized by crop life stages. Key control measures and their alternatives (current and potential) are discussed. A foundation for a pest management strategic plan is proposed. Differences between production regions represented are discussed where appropriate.

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

PRODUCTION REGIONS

Alfalfa and clover seed are produced throughout the western United States. This document represents growers in California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. Within these states, the production areas can be broken down into the following regions:

- Idaho and Oregon's Treasure Valley (alfalfa/clover),
- Utah and Nevada (alfalfa),
- Montana (alfalfa) and Wyoming (alfalfa and clover),
- Oregon and Washington's Columbia Basin (alfalfa/clover),
- Walla Walla Valley (alfalfa),
- California (alfalfa), and
- Western Oregon (clover).



Treasure Valley

The Treasure Valley lies in southwestern Idaho (Canyon and Owyhee counties) and eastern Oregon (Malheur County). Other counties in southwestern and south central Idaho produce some alfalfa seed, but the acreage and number of producers is limited. Idaho produces approximately 25% of the U.S. alfalfa seed crop and is the leading U.S. producer of winter-hardy alfalfa seed. From 1995 through 2003, an average of 35,000 acres of alfalfa seed were harvested in Idaho, though acreage has trended lower in recent years (e.g., Idaho's portion of Treasure Valley harvested 46,000 acres in 2000 and 15,000 acres in 2003, a trend that is echoed in other western regions as well). Seed yield for 1995–2003 averaged over 700 pounds per acre providing an annual production of over 24 million pounds of seed valued at more than 30 million dollars. Annual production costs for alfalfa seed range from $500 to $800 per acre in the irrigated regions.

Seed production in Oregon accounts for approximately 6% of the U.S. total. Since 1995, seed production throughout Oregon has averaged over 6 million pounds on approximately 8,500 acres annually, with most of this production taking place in eastern Oregon's portion of the Treasure Valley. Yields have averaged 680 pounds per acre valued at more than 8 million dollars per year.

The Treasure Valley accounts for approximately 5% of the clover seed grown in the Pacific Northwest. Most of this production is in red clover seed and takes place in western Idaho. Clover seed acreage in Idaho has declined from 3,500 in 2000 to 1,200 in 2003. Average yield in 2003 was 560 pounds of seed per acre.

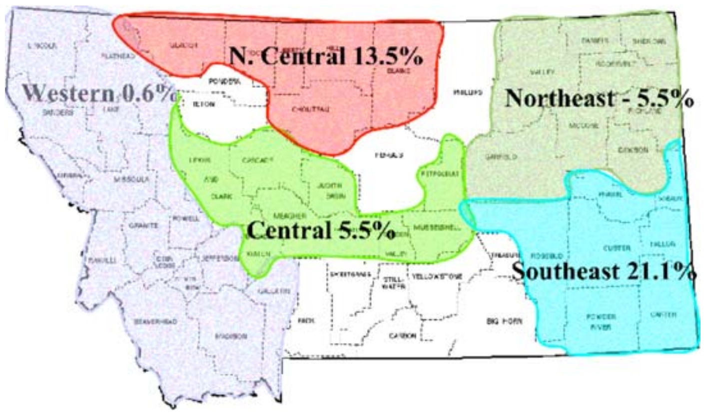
Utah and Nevada

Utah alfalfa seed is primarily produced in Box Elder, Weber, and Millard counties. Small amounts of alfalfa seed are produced in Cache and Juab counties, and on rare occasions, it is also produced in Uintah and Duchesne counties. Utah has both certified and non-certified alfalfa seed production. Certified seed by definition has known germplasm identity, high genetic purity, high germination ability, and minimum amounts of other seed and inert matter. In general, certified seed has a higher market potential. Ninety percent of the certified alfalfa seed production is located in Box Elder and Weber counties, with the remaining 10% in Millard County. Approximately half of the non-certified acres start out as alfalfa hay acres, but are left to go to seed when there is a water shortage. In 2004, there were 1,432 acres of certified alfalfa seed production in Utah. Non-certified production is estimated at 3,500 acres. Yield for certified seed is estimated at 912,000 pounds total for 2004, with a historical average of 950 pounds per acre. Average yield for non-certified alfalfa seed is 550 pounds per acre, or 2,000,000 pounds of total seed production. Certified alfalfa seed production is described in more detail in the Production Issues section, "Crop Rotation and Isolation."

Alfalfa seed production in Nevada is concentrated in Humboldt and Pershing counties. Only 4,500 acres of alfalfa seed were harvested in Nevada in 2003, down from 6,000, 9,500, and 14,500 acres in 2002, 2001, and 2000, respectively. Drought in Pershing County and a decline in contracts from seed dealers have contributed to this production decrease. Yields have been consistently above 600 pounds per acre (680 pounds per acre in 2003). Annual production is valued at 3.4 billion dollars. Alfalfa seed produced in Nevada and Utah combined accounts for approximately 5% of total U.S. production.

Montana and Wyoming

Montana alfalfa seed production has ranged from 6,200 to 20,000 acres annually over the last 5 years and is distributed throughout the state. The map following illustrates percentage alfalfa seed production in each region of the state. Between 60 and 75% of Montana's alfalfa seed acreage is irrigated. Of the remaining (dryland) production, much of the crop is originally planted as alfalfa hay, but due to drought or other production considerations, the grower allows the crop to go to seed and harvests seed rather than hay. Over the last 10 years, Montana has averaged 13,120 irrigated acres, yielding an average of 290 lbs. seed per acre. Dryland yields vary a great deal, averaging 134 lbs. per acre over the last 5 years on an average of 5,400 acres.



In Wyoming, alfalfa and red clover are grown for seed in the Big Horn Basin in the northwestern part of the state, encompassing Park, Big Horn, and Washakie counties. The area is known for its dry harvest weather. Alfalfa seed production has ranged from a high of 17,000 acres prior to the bankruptcy of Agribiotech in 2000 to a low of just under 2,000 acres in 2003, with an average of 8,524 acres annually from 1999 through 2003. Acreage for 2004 (not including any fall-seeded acres) was just over 3,500. Seed yields in 2003 were 700 pounds per acre on established stands, and 250 pounds per acre on seed-to-seed acres, with an overall average yield of 590 pounds per acre from 1999 through 2003. Red clover seed is produced on fewer than 1,000 acres with yields of approximately 500 pounds per acre. Some Roundup Ready alfalfa seed acres have been planted in Wyoming, even though the seed harvested from these acres cannot yet enter the market. They are going in under strict guidelines and one-mile isolation requirements, to avoid cross pollination between GMO and non-GMO alfalfa seed. Isolation requirements are described in more detail in the Production Issues sections “Crop Rotation and Isolation” and “Genetically Modified Organisms.”

Columbia Basin

In 2003, alfalfa seed was produced on 8,164 acres in Washington and Oregon’s Columbia Basin. Washington’s Grant County reported 5,900 of those acres, with production centering on the town of Warden, southeast of Moses Lake. Dormant cultivars dominate; however, there is some production of semi-dormants. Non-dormant varieties are usually planted in mild winter areas for their ability to grow in the late fall, winter, and early spring. Semi-dormant and dormant varieties are adapted to colder winter areas above 4,000 feet in elevation. Non-dormant and semi-dormant alfalfa varieties generally have higher yield potential, but are more susceptible to winter injury. Dormant varieties typically mature later, but persist better for long-term stands. The primary pollinator is the leafcutting bee, however, there are a few alkali bee beds in the region. More detailed information on pollinators is provided below in the Production Issues section, under

Pollination. Average alfalfa seed yields are 782 pounds per acre in the Columbia Basin, with consistent yields of 1,000 pounds per acre for some growers. The region produces 4.5% of total U.S. alfalfa seed.

Currently, there are 476 acres of red clover seed production in Grant County, Washington.

Walla Walla Valley

Production of alfalfa seed in Walla Walla Valley, in Walla Walla County, Washington, stretches from the town of Touchet in the southwest part of the county, east to the city of Walla Walla. The bulk of that production takes place just south of Touchet. There were 6,100 acres planted to alfalfa seed in Walla Walla County in 2003, yielding 59,000 cwt. of seed. Two irrigations per year are sufficient in Walla Walla due to the deep, well-drained soils. The alkali bee, a native pollinator, thrives in this area. (More detailed information on pollinators is provided below in the Production Issues section, “Pollination.”) With the help of this pollinator, growers are able to achieve very high yields, as demonstrated by the 920 pounds per acre yield recorded for the 2003 crop.

California

Alfalfa seed production in California is located in the central San Joaquin Valley (Fresno and Kings counties), the Imperial Valley, and Yolo County. Over the past ten-year period, California harvested an annual average of 50,700 acres of alfalfa seed averaging 523 lbs of seed per acre, for a total of 26.9 million pounds of seed per year. Ninety-five percent of the seed produced in California is of the non-dormant varieties, whereas most of the rest of the alfalfa seed production in the western United States is of the dormant to semi-dormant varieties. California alfalfa seed production accounts for 30 to 40% of national production.

Western Oregon

The Willamette Valley of western Oregon produces 95% of all clover seed grown in the Pacific Northwest. Total rainfall in the Willamette Valley is more than 40 inches per year, though it rarely rains in July and August. This unique climate allows clover seed to be grown without irrigation yet the mature crop can dry in the fields without threat of rain. Harvested acres have averaged 35,785 over the past 10 years, with yields of 378 to 823 lbs of seed per acre depending upon type. The clover seeds grown in western Oregon are primarily red (*Trifolium pratense* L.), a perennial clover, and crimson (*Trifolium incarnatum* L.), which is produced annually. Production of arrowleaf (*Trifolium vesiculosum* Savi.) and white or ladino (*Trifolium repens* L.) clover is very minor. Red and crimson, clover seed are grown mostly in Washington, Yamhill, and Polk counties. Red clover is the predominant species, produced on approximately 50% of Oregon clover seed acres, and crimson clover is the second most commonly planted clover seed species, produced on approximately 30% of Oregon clover seed acres.

PRODUCTION ISSUES

Pollination

Without bees, there could be no production of alfalfa seed or red clover seed, as cross-pollination is necessary for seed set in both crops. (Crimson clover seed, grown only in western Oregon, is self pollinated; no pollinator bees are needed for seed production.) The two major pollinators of alfalfa seed in the Northwest are the alkali bee*, Nomia melanderi,* and the alfalfa leafcutting bee, *Megachile rotundata*. The alkali bee nests in the ground in natural or artificial sites, while the leafcutting bee spends its life above ground in artificial nests and shelters. The honey bee, *Apis mellifera,* is the pollinator of choice for alfalfa seed production in California. Pollination of clover seed is generally accomplished by honeybees although naturally occurring pollinators such as bumblebees, *Bombus* spp., are quite beneficial when encountered in the field. In fact, in western Oregon, bumblebees are equally, if not more, efficient at pollinating red clover seed than honeybees, due to their habit of spending the night in the field, rather than in a hive as honeybees do.

Growers either culture their own pollinator bees or hire a pollinating service. Either way, the timing of bee placement in the field is selected to maximize seed set and to allow sufficient time for bee reproduction. While California growers hire custom pollinators exclusively, many growers in other Western states derive income from both their seed crop and from the sale of the bees they raise beyond what is needed for the next year's pollination. Bee populations are replaced annually. The pollinator industry is a multi-million dollar agribusiness built around nesting materials, domiciles, predator and parasite traps, and bee production.

All managed pollinators need protection from diseases, parasites, predators, and harmful insecticides. Alfalfa seed growers lose up to 50% of their leafcutting bees to diseases, parasites, and pesticides during the pollination season. The biggest problem is leafcutting chalkbrood disease, which is similar to honeybee chalkbrood, but is specific to leafcutting bees. Larvae infected with the fungal pathogen *Ascosphaera aggregata* Skou die before reaching maturity. The second most important problem facing leafcutting bee management is loss due to parasitism and predation. At least 8 parasitic species and 28 predator or nest-destroyer species are known to infest leafcutting bees or their nest materials. Specific bee health problems vary by pollinator and growing region. In California alfalfa seed production, as well as in Oregon and Idaho red clover production, Varroa and tracheal mites are significant problems in honeybee hives. In Wyoming, the main challenges are chalkbrood, pollen balls, and *Pteromalus* spp. parasites. The work ongoing at the Logan Bee Lab dealing with bee health is very important to alfalfa and clover seed producers.

Integrated Pest Management

Pollinator management represents 20 to 30% of the per-acre costs of alfalfa seed production. Largely as a result of the critical need to conserve pollinators, the alfalfa and clover seed industries were early adopters and implementers of the integrated pest management (IPM) concept; they formed the first multi-state IPM program in 1976.

Integrated management of pests in alfalfa and clover seed production incorporates chemical, cultural, and biological control methods to prevent economic yield loss, to mitigate resistance development, and to protect populations of beneficial insects. Beneficial insects in this context include both the pollinators and the predators and parasites of insect pests that help to maintain pest populations below damaging levels.

Successful alfalfa and clover seed IPM begins with scouting/monitoring, especially in the case of arthropod pests. Growers or their contracted agents (field scouts and pest control advisors) monitor most pest and beneficial insect populations consistently throughout the season. Both population counts and the developmental stage of pest and beneficial insects and mites in relation to economic thresholds are used to determine management strategies. Continuous monitoring of pest and natural enemy populations in the field can result in reduced use of chemicals, improved timing of pesticide applications, and less disruption of natural enemy and pollinator activity.

A number of arthropod pests can reduce yield and/or quality of alfalfa and clover seed. The major pests in all alfalfa seed-growing areas are lygus bugs (*Lygus* spp.), spider mites (*Tetranychus* spp.), alfalfa seed chalcid (*Bruchophagus roddi*), and various species of aphids, including pea aphid (*Acyrthosiphon pisum*), blue alfalfa aphid (*A. kondoi*), spotted alfalfa aphid (*Therioaphis maculata*), and cowpea aphid (*Aphis craccivora*). In clover seed, pea aphids are the most serious pest, followed by spider mites on irrigated acreage. In most years, these pests exceed established thresholds and require control in most areas. Occasionally stinkbugs (various species) and armyworms (*Spodoptera* spp.) also require control measures. The biological, cultural, and chemical control options for managing insect pest populations in alfalfa and clover seed are limited by a number of factors.

Biological control involves the use of naturally occurring or released predators and parasites including minute pirate bugs (*Orius* spp.), big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and lacewings (*Chrysopa* spp.). Spiders, ladybird beetles, and parasitic wasps also contribute to management of various pest species. Integrated pest management programs for management of alfalfa and clover seed pests have emphasized conservation of natural enemies through judicious use of pesticides. Growers try to apply non-selective pesticides such as bifenthrin (Capture) only when significant numbers of natural enemies or pollinators are not present in fields. When possible, they use selective pesticides such as pirimicarb (Pirimor) for aphids and oxydemeton-methyl (Metasystox-R) for early instar lygus bugs, both of which are relatively safe for big-eyed bugs and damsel bugs. In most cases, biological control alone cannot be relied upon to provide economic control in seed fields.

Cultural controls have a limited effect on most pests in alfalfa seed fields; typically, they are used in conjunction with other management methods. The most effective example of cultural control of an insect is the early clip-back and fall management strategies used to suppress alfalfa seed chalcid populations. Clip-back (also known as set-back) is the cutting of the crop after establishment to synchronize the flowering period with pollinator presence. These management strategies are described later, in the Vegetative Growth crop-stage section.

Chemical control is currently the most effective and widely used pest management option, but is not without problems. Chemicals must be carefully selected and applied to kill the target pest with a minimum impact on pollinator and beneficial arthropods. Nearly all of the chemicals used for pest management purposes in seed alfalfa are capable of killing bees by direct contact. Typically an insecticide is applied in May before bees are placed in seed fields. When applications are required during bloom, applicators protect pollinating insects by applying chemicals according to their written labels. Growers are particularly aware of instructions specifying locations of pollinators with respect to treated areas and chemicals used and night application start- and stop-time limits. Fields are inspected for bee activity before applications. The condition of pollinators, air temperature, and field conditions can vary greatly; visual inspection prior to beginning a pesticide treatment is the best way to avoid direct contact between pesticides and bees. Chemicals may be applied by air to avoid the plant damage caused by driving through the field. There are only a few materials available to control the most damaging insect pests in seed alfalfa fields. For this reason, resistance management is an important consideration. Maintaining the susceptibility of insect populations to chemicals is critical. Growers, field scouts, and pest control advisors take the population of beneficial insects in the field into consideration, use selective materials first when possible, and monitor resistance to make more informed pest management decisions.

Crop Rotation and Isolation

A number of crops are available for rotation with alfalfa and clover seed, including small grains, corn, sugarbeets, onions, and potatoes. Cotton and safflower are also part of the rotation in California. Specific crop rotations for each region are detailed in Tables 1 and 2 in the Pre-Plant/Establishment crop-stage section. The selection of a particular crop for use in rotation will depend on a number of regulatory, economic, biological, and contractual factors. Most alfalfa and clover seed is produced on contracted acres. (Clover seed grown in western Oregon is the exception; typically only certain proprietary varieties are grown under contract in this region.) Contracts often specify temporal and or spatial restrictions with regard to crops and crop varieties, and isolation distances that must be met before planting a field to alfalfa or clover seed.

To maintain genetic purity, certification standards require minimum distances between the alfalfa and clover seed field in question and fields of any other variety. For certification as "Certified Class" seed, an isolation distance of 165 feet is generally required. Isolation distances required to meet certification standards as "Registered" and "Foundation" seed vary among states but are more stringent (see http://www.aosca.org/aoscaflash.html for more details on isolation distances). Contracts will also often specify conditions for adequate take-out of an alfalfa or clover seed variety: fields, for example, may not be permitted to be used as forage after seed harvest. Furthermore, a field planted to clover seed cannot be planted to alfalfa seed immediately following take-out.

In many cases, an alfalfa seed crop begins as an alfalfa hay crop. Towards the end of the season, when irrigation water is scarce, or if other environmental factors contribute to a reduced hay production, growers allow their alfalfa hay crop to go to seed, and that seed is harvested. In this case, the seed would not be certified.

The use of certain herbicides to control problem weeds can limit the choice of a rotational crop. For example, imazethapyr (Pursuit) is labeled for post-emergence annual grass and broadleaf weeds. Plant-back restrictions vary by rotational crop, but the plant-back restrictions for potato and sugarbeet are 26 and 40 months, respectively. Similarly, rotations with sugarbeets, corn, and a number of grass crops are not permitted within 12 to 20 months following application of trifluralin (Treflan), and alfalfa seed fields cannot be planted to another crop within two years of applying hexazinone (Velpar, used only in California).

Crop rotation can aid in control of some nematodes. Infestations of alfalfa stem nematodes may be controlled by rotating to a non-host crop such as grains, beans, or sugarbeets. Infestations of northern root-knot nematodes may be reduced by rotation to cereal crops, which are poor hosts for this nematode. In contrast, grains (specifically, wheat and barley) are hosts for the Columbia root-knot nematode, and rotation is less effective for control of this pest. Nematode management in alfalfa and clover seed is detailed in later sections.

Non-Food Status

Certain alfalfa seed grower associations in Washington, Oregon, Idaho, Montana, Nevada, and Wyoming have declared, through their respective state departments of agriculture, that alfalfa produced for seed in those states is a non-food crop. These regulations guarantee that none of the seed, screenings, or hay will be available for human or animal consumption when non-food pesticides have been applied, and that the commodity is exempt from tolerance regulations. Some labels specify that no part of the alfalfa plants that have been treated with a certain product may be used for feed or food (including grazing) for a specified number of months from the date of the last application.

In California, the process is a little different. When chemicals are registered for use on seed alfalfa via the Section 24c (Special Local Needs) process, there is often a label requirement that a *Seed Conditioner Notification* statement be completed and delivered with the seed to the conditioner. Growers and seed conditioners are equally responsible to ensure compliance. This requirement is specified for alfalfa seed treated with crop protection chemicals governed by California Food and Agriculture Code Section 12832. The label language is the same or similar to the rules provided by the non-food regulations in other states.

Note that red clover in western Oregon is cut for forage just before bloom (similar to clip-back/set-back in alfalfa seed, but referred to as “flailing”). Since the first cutting is utilized as a feed crop, pesticides used in red clover production must have tolerances.

Genetically Modified Organisms (GMOs)

In recent years, alfalfa seed companies have been conducting research to add value to alfalfa forage by developing genetically modified (GMO) alfalfa. The first genetically engineered trait to enter the commercial marketplace will be Roundup Ready™ (RR) alfalfa using transformation technology. As the name implies, alfalfa with this gene will not be affected by the herbicide Roundup. The seeds for the varieties with this trait will most likely be grown somewhere in the current seed growing areas of the northwestern United States. Monsanto and its research partner, Forage Genetics, plan the first release of RR alfalfa products in 2005. However, they have indicated that they will not release the products until they gain regulatory acceptance of GMO alfalfa in Japan and China. No RR clover seed germplasm is being developed.

RR alfalfa will allow for less competition from weeds at establishment and the potential for producing a weed-free crop due to the tolerance to glyphosate. It will allow for effective control against a broad array of weeds with a wide window of application. However, wherever RR alfalfa seed production is introduced, it will bring with it challenges the seed production industry has never faced. Issues will include customer acceptance, crop removal, cross-contamination, organic compliance, increased herbicide use, resistant weeds, segregation of GMO and non-GMO seed all the way from harvest to cleaning, crop rotations between GMO and non GMO alfalfa seed varieties, take-out of GMO fields, and virus recombination.

While the release of RR alfalfa would provide another excellent tool for weed control, seed producers are very concerned about the impacts on the export market because of the current weak acceptance of GMOs in Pacific Rim countries. The ability to distinguish GM alfalfa from conventional alfalfa could aid in the introduction of GM products; Monanto is developing inexpensive test kits for this purpose.

Alfalfa seed production is different from many other seed crops because it requires the use of bees to pollinate the crop. Both naturally present and introduced bees move pollen with them wherever they go, and in some cases they may move several miles before landing in another alfalfa seed field. The significance of this is that as bees move pollen from one field to another they may introduce GMO traits to non-GMO alfalfa seed fields. Consequently, a GMO alfalfa seed grower could be in jeopardy due to their failure to control the flow of the trademarked and protected RR pollen. The grower of the non-GMO alfalfa seed may have an adventitious presence of a GMO organism in their crop, thereby risking a contract rejection.

As explained in more detail later in the Take-Out/Stand Removal section, many growers use broad-spectrum, contact herbicides such as glyphosate (Roundup) to desiccate and remove the alfalfa seed crop at the end of the production cycle. The use of RR alfalfa will eliminate that option in GMO fields. Other herbicides are available to help with stand removal, but they will likely require tillage operations such as crowning or disking to supplement the procedure.

Reports show a significant increase in the use of glyphosate when a RR system is adapted. Alfalfa would not likely be an exception to the trend. Glyphosate is generally believed to be immobile in soil and have a low acute toxicity to mammals. But there are some concerns about harmful affects if administered at high doses over long periods of time. For example, with the increase in adoption of the RR system follows the potential increase of glyphosate-resistant weeds. With the continuous use of the same herbicide, there is a natural selection for resistance to the herbicide over time. Tolerant weedy plants that survive the applications may cross and become more resistant to glyphosate. There are some weeds that have already shown more tolerance to the herbicide. The possibility of losing other current herbicides due to lower usage as a result of replacement with glyphosate is of concern as well.

There is some concern about the risks of transgenes from feed being passed on to gut microflora in livestock. Along with the gene that confers glyphosate resistance, an additional gene must be inserted to activate the process. The gene is called a promoter; the one Monsanto uses with the RR trait is from the Cauliflower Mosaic Virus (CMV). The concern is the CMV potential to reactivate dormant viruses as well as recombine with them to create new viruses.

PRE-PLANT/ESTABLISHMENT
(FIELD SELECTION, LAND PREPARATION, AND STAND ESTABLISHMENT)

This crop-stage section deals with pest management activities and concerns during field selection, land preparation, and establishment of the seed-producing stand. Since alfalfa and clover seed are generally grown as perennial crops in which the seed harvest does not occur until the second and subsequent years, the establishment phase can include the entire first year. Consequently, this section addresses practices before planting, at planting, and throughout the first year in the field, including the full spectrum of seasonal pest pressures. The crop-stage sections following (Vegetative Growth, Pollination and Seed Set, Seed Maturation, Harvest, Post-Harvest, and Dormancy) refer to the annual stages the crop goes through during its production years, typically years 2-4 of the crop.

Some of the regions represented in this document can harvest alfalfa and clover seed the same year the crop is planted (e.g., California, the Treasure Valley, and the Columbia Basin). In some cases, growers even have single-year contracts with the seed companies, meaning alfalfa and clover seed are treated as annual crops.

Although alfalfa is adapted to a wide range of soil conditions, best results are achieved using deep, medium textured, well-drained soils. Poorly drained, saline soils, as well as soils with a high water table, are avoided. The soils must be able to support a rooting depth of at least 40 inches. Soils that have a high water-holding capacity are preferred over sandy soils; soil texture should be moderately clay-rich to enhance water retention. Soils underlain by coarse gravel are avoided due to leaching, while soils underlain by hardpan layers are avoided because of poor drainage.

As previously mentioned under “Crop Rotation and Isolation,” alfalfa and clover seed fields must be isolated from other alfalfa and clover seed fields of different varieties. A field sheltered from the wind benefits pollinator bees, increasing the efficiency of pollination in the field. Removal of stray alfalfa plants from border areas, ditch banks, and road rights-of-way will help isolate alfalfa and clover seed fields. In fact, a buffer zone between alfalfa and clover fields is critical to lower the chances of out-crossing.

Cultural practices for alfalfa seed production are significantly different than for alfalfa hay production. Alfalfa and clover seed are produced primarily in the western United States. All alfalfa seed, and all irrigated red clover seed (Idaho, Washington, Wyoming), is grown in a semi-arid region that receives 10-14 inches of annual precipitation. This precipitation is concentrated in the late fall, winter, and early spring. These dry conditions, especially during the growing season, allow for adjustment of irrigation to encourage maximum flowering activity while preventing over-development of foliage. Water is applied early and mid-season to promote vegetative growth and is curtailed in late season to allow soil drying. Soil drying stresses the seed crop and leads to a decline in vegetative growth, enhanced flowering and pollination, and finally seed formation. Sparse irrigation also provides a favorable foraging environment for pollinators. All alfalfa seed produced in the Treasure Valley, Nevada, Utah, Walla Walla, Columbia Basin, Wyoming (6” of annual precipitation), and California is grown under irrigation.

Only 60-75% of the acres in Montana are irrigated. All of the red clover seed grown in Idaho, Washington and Wyoming is irrigated, while none of the clover seed acres in Western Oregon are irrigated. Tables 1 and 2 detail the irrigation, planting, and crop rotation regimes in each region. Irrigation management is becoming critical to IPM. Clover seed (both red and crimson) grown in western Oregon is rainfed; no irrigation is necessary. Clover seed in this region is not water stressed.

The alfalfa and clover seed growing season ranges from 105 to 180 days. Differences of 40 to 50° F between day and night temperatures frequently occur during the growing season in parts of the Pacific Northwest, while in California, nighttime temperatures do not drop as much.

Time of seeding will affect pest management practices. Seeds may be sown in fall or spring. In cold climates such as Wyoming and Montana with extended freezing periods, spring planting is the norm. In many of the other areas, fall planting is preferred, due to the resulting higher yields. Fall planting is dependent on available contracts, crop rotation and the ability to burn, because planting in the fall leads to increased winter annual weeds and spring burning is the preferred method for control of these weeds. In areas where burning is allowed, planting is a three-step process: burn, harrow, plant. Although field burning is a controversial issue due to air quality concerns, the benefits associated with burning outweigh the disadvantages. Where burning is not allowed, residue management is problematic and the field is left vulnerable to wind erosion and run-off. In the absence of burning, there can be increased infestations of weeds and insects (e.g., alfalfa weevils and the alfalfa seed chalcid), which can lead to an increase in herbicide and insecticide use. Burning is not necessary for residue management in western Oregon and is not practiced.

Alfalfa grown for seed is planted in much thinner stands than that grown strictly for forage. This is a practice that enhances seed production by reducing the number of aborted flowers, competition between plants, lodging, and foliar disease levels. Thin stands also allow pollinators to work much more efficiently, enable more even application of pest control agents, and facilitate better control of volunteer alfalfa, all of which results in more seeds per plant. Alfalfa grown for seed is planted in wider rows and rows contain fewer plants than alfalfa grown for forage. Clover grown for seed is planted in denser stands than alfalfa grown for seed. Row widths and seeding rates for each region are listed in Tables 1 and 2. Once the stand is established, the field is cultivated in the spring to further thin the stand and to destroy weeds. In-season cultivation is not practiced in western Oregon.

A well-worked seedbed is a requirement for good establishment. Land preparation typically involves disking or plowing to break up heavy subsoil, with final leveling. Summer fallow the year prior to establishment is used in Montana. Phosphorous and potash can be applied before planting to correct soil nutrients, if these are low. Lime is generally added in western Oregon to maintain proper pH. Some growers plant in moistened seedbeds while others plant in dry soil and irrigate afterward.

Table 1: Planting Facts for Alfalfa Seed Production

	Regions				
	Treasure Valley, Utah, Nevada	**California (Central and Imperial Valley)**	**Columbia Basin (WA)**	**Walla Walla Valley (WA)**	**Montana, Wyoming**
Crop Rotations	**TV, NV**: Grain, Sugarbeets, Potatoes, Beans, Corn, Mint, Onions (TV only). **UT**: Grain and Corn	Cotton, Safflower, Wheat	Grains, Corn, Peas, Vegetable Seeds, Potatoes, Onions, Grass Hay	Grains, Dry Peas	Barley, Beans, Corn, Summer Fallow (rarely practiced)
Planting Dates					
Fall	Mid-Aug to Sept	Mid-Sept to end of Oct (best), but continues through early Dec.	Aug to Sept	July to Sept	Aug 15
Spring	Mid-Feb to April	Mid Jan to late Feb	Mar to April	Feb to April	April 1 to 20
Row Widths	22 to 34 inches, depending on rotational crop	30 inches flat or bedded	22 or 30 inches	22 to 30 inches, or broadcast	22 to 24 inches, sometimes 30 inches
Seeding Rate (lbs. per acre)	1/4 to 2	1/2 to 2	1/4 to 2	1 to 2	1 to 2
% Irrigated	100%	100%	100%	100%	60 to 75%
Gravity	85%	100% (furrow and flood)	60%		90% of total
Hand Lines		Sprinklers used occasionally for establishment.		100%	
Center Pivot	15%		40%		10% of total
Wheel Lines					

Table 2: Planting Facts for Clover Seed Production

Clover Seed – All Regions	
Crop Rotations	Mostly grains and grass; some corn, sugarbeets and onions. Dependant on region and plant-back restrictions
Planting Dates	
Fall	Aug 10–Sept 10 (Sept–Oct for crimson clover)
Spring	March 1–April 15
Row Widths	Drilled; between 12 and 22 inches
Seeding Rate	2 pounds per acre
% Irrigated	
Western Oregon	0%
All Other Regions	100%
%Gravity	80%
% Hand Lines	10%
% Center Pivot	10%

Nematodes

Nematodes are a common pest in alfalfa seed production in the Pacific Northwest and can cause substantial losses to stands and yields under certain conditions. They are currently not a problem in clover seed fields or in California alfalfa seed fields. The five most important nematodes are the northern root-knot nematode (*Meloidogyne hapla*), Columbia root-knot nematode (*M. chitwoodi*), southern root-knot nematode (*M. incognita*), alfalfa stem nematode (*Ditylenchus dipsaci*) and various lesion nematodes (*Pratylenchus* spp.). Nematodes can adversely affect emergence and establishment of young seedlings and also permit other organisms to attack the plant. They cause direct damage to alfalfa roots and stems, and can impact other crops grown in rotation with alfalfa. Nematodes are easily spread long distances by soil movement, irrigation water, nursery stock, seed, and seed debris.

Root-Knot Nematode

Northern Root-Knot Nematode *(Meloidogyne hapla)***, Columbia Root-Knot Nematode** *(M. chitwoodi)***,** and **Southern Root-Knot Nematode** *(M. incognita)*

Northern and southern root-knot nematodes are present throughout the United States, whereas the Columbia root-knot nematode is only found in the Columbia Basin, Idaho, California, Colorado, Wyoming, Montana, and parts of Nevada. Root-knot nematodes thrive in moist, sandy loam soils. They live as parasites in the root tissue of alfalfa and a number of other hosts. Grain crops are poor hosts for the northern root-knot nematode. In contrast, grains (specifically, wheat and barley) are hosts for the Columbia root-knot nematode. Two races of the Columbia root-knot nematode, race 1 and race 2, occur in Idaho, but only race 2 is able to reproduce on susceptible alfalfa varieties. Potatoes, beans, and sugarbeets are also host crops.

Damage: Root-knot nematodes are infectious only when they are newly hatched, second-stage juveniles. As the alfalfa seedling develops, juveniles in the root become established and begin feeding. Small galls develop and excessive branching occurs on the roots at the feeding site. The galls may resemble nitrogen-fixing nodules, but can be distinguished since healthy nodules are generally pink. The extent of the damage within the field depends on the initial nematode population, presence or absence of a resistant variety, and warm soils at planting. Root-knot nematodes encourage plant infection by bacterial wilt, Phytophthora root rot, and Fusarium wilt pathogens.

Cultural Control: Planting resistant varieties is the most practical way to manage root-knot nematodes. Crop rotation is not a successful management tool, because over 550 species of plants are hosts. Nematodes may be distributed by irrigation water. Pre-plant sampling for nematodes helps determine their presence and the extent of any infestation.

Chemical Control: Soil fumigants used pre-plant may be feasible where severe nematode problems have been encountered. However, fumigants are expensive and not usually economically feasible. No non-fumigant nematicides are registered for alfalfa.

Alfalfa Stem Nematode (*Ditylenchus dipsaci*)
Alfalfa stem nematodes are more destructive in older fields and in irrigated regions, especially where waste water or tail water is used. They hatch from eggs and go through four stages, or “molts,” any of which can infect the plant. The nematodes congregate under developing leaflets at or near the soil surface and penetrate the young succulent stem or bud tissue. Alfalfa stem nematodes can be introduced into fields through uncleaned, infested seed, other infested plant tissue, or contaminated manure, irrigation water, or machinery. Researchers in Washington State have found evidence that the alfalfa stem nematode can infect potatoes as well, making a rotation with potatoes undesirable. Not all races of the alfalfa stem nematode will infect potatoes, but there is currently no diagnostic tool to determine which race of the nematode is present in the field. A joint research project with WSU and USDA in Wyoming is planned to find molecular markers for the different races, hopefully making a diagnosis more plausible.

Damage: Stem nematodes are one of the few groups of nematodes that feed mainly on above-ground plant parts and rarely on roots. Patches of poor, stunted growth and bare patches where weeds can invade are indicative of alfalfa stem nematode damage. The bases of infected stems become swollen, discolored, and roughened. This also causes swollen nodes and shortened internodes. Plant crowns and lower stems are thickened. Plant vigor and overall plant and stand survival are reduced. Stem nematodes feed on plant tissues and kill chloroplasts, which causes leaves to turn white. Severely infected plants die. This damage primarily occurs in early spring and fall as the temperatures cool. Root feeding causes gall-like outgrowths that may girdle the root crown.

Cultural Control: Control of these pests is best accomplished by rotating to non-host crops and planting an alfalfa seed cultivar that has resistance to the nematode. Planting clean, nematode-free seed is one of the first lines of defense against nematodes. Fall burning also decreases nematode infection, but spring burning appears to enhance infection and increase plant mortality. A methodology for pre-plant nematode sampling is needed.

Chemical Control: No nematicides are registered for use against the alfalfa stem nematode and pre-plant fumigation rarely proves economical.

Root Lesion Nematode (*Pratylenchus* spp.)
Root lesion nematodes are found throughout the world in temperate and tropical regions. Like root-knot nematodes, lesion nematodes have a wide host range that varies from crops to weeds. They are most destructive to roots of cultivated and non-cultivated plants in sandy or sandy loam soils. Many species of root lesion nematodes are associated with alfalfa. The most economically important species of lesion nematode is *Pratylenchus penetrans*, but this species is relatively uncommon in Idaho. The most common species in Idaho are *P. neglectus* and *P. thornei*.

Pratylenchus species are migratory, endoparasitic nematodes that can invade plant roots at all stages of the life cycle outside the egg (similar to the stem nematode). As in the stem and root-knot nematodes, second-stage juveniles of root lesion nematodes emerge from eggs (nematodes typically undergo their first molt inside the egg). Lesion nematodes penetrate the entire root system, except root tips, by forcing their way between or through epidermal and cortical cells. They feed on cell contents as they migrate within roots. Females deposit eggs in root tissue or soil, where the eggs in plant tissue or in soil survive winters. Females do not survive winters in Idaho.

The most important method of dissemination of root lesion nematodes is probably contaminated irrigation water, machinery, or tare dirt. Plants infected with root lesion nematodes do not show above-ground symptoms that can positively aid in nematode identification. Above-ground symptoms are more general, and can include stunting and nutrient deficiencies. Root lesion nematodes reduce root growth and inflict black or brown lesions on the root surface. Lesions may fuse to cause the entire roots to appear brown. Secondary infections of roots by other bacterial and fungal pathogens commonly occur after root lesion nematode invasion. Alfalfa resistance to these secondary pathogens may sometimes be overcome due to root lesion nematode invasion.

Cultural Control: Since lesion nematodes have a very wide host range, and more than one species may occur in a field, crop rotation is not effective for lesion nematode management. However, leaving a field fallow, followed by treatment with a nematicide, can reduce lesion nematode populations. Alfalfa germplasm with resistance to lesion nematodes has been developed. However, alfalfa varieties with adequate resistance are not yet commercially available. When varieties with satisfactory resistance to one or more *Pratylenchus* species become available, they will probably be the best means of controlling lesion nematodes since the cost of chemical control is prohibitive. Pre-plant sampling for nematodes would be effective, but is not available.

Critical Needs for Management of Nematodes in Western U.S. Alfalfa and Clover Seed during Pre-Plant/Establishment

Research

- Find non-fumigant seed treatments for root-knot and lesion nematode control.
- Develop commercially viable alfalfa and clover varieties resistant to nematodes.
- Research cultural management methods for nematodes, especially for stem nematode.
- Understand nitrogen mineralization following green manure crops.
- Investigate the use of green manure crops for nematode management in preparation for spring planting.
- Develop pre-plant sampling method for nematodes.

Regulatory

- Facilitate phytosanitary certification of seed and testing for seed exports leaving the U.S. (i.e., nematode screening in the debris with the seed, not within the seed).
- Expedite registration of future nematode seed treatments.

Education

- Provide better information on the varietal resistance to different species of nematodes.
- Educate growers on benefits of growing alfalfa seed following a crop that has been fumigated for nematodes.
- Educate growers on benefits of using nematode-resistant varieties for nematode management on other crops.
- Provide extension publications on management of alfalfa nematodes.

Weeds

The most important factor in field selection is the weed spectrum present. Weeds compete with the seed crop and can reduce the stand, plus weed seed contaminates the harvested crop (see Post-Harvest crop-stage section). Weeds can attract pollinator bees away from alfalfa and can also attract pest insects.

Annual weeds, especially prickly lettuce (*Latuca serriola*), sow thistle (*Sonchus oleraceus*), hairy nightshade (*Solanum sarrachoides*), kochia (*Kochia scoparia*), and common lambsquarters (*Chenopodium album*), are a problem during and after establishment. Certain noxious weeds are not allowed in alfalfa and clover seed lots offered for sale and should be systematically eliminated from seed fields, beginning at this crop stage. It is important to eliminate perennial weed problems before planting alfalfa and clover seed.

Sweet Clover *(Melilotus* spp.*)* and **Yellow Sweet Clover** *(Melilotus officinalis)*

Sweet clover in general, and yellow sweet clover in particular, are considered pests in alfalfa seed crop plantings. For this reason alfalfa seed growers avoid planting to fields with a history of sweet clover.

Dodder (*Cuscuta* spp.)
Dodder is one of the most troublesome weeds in alfalfa and clover seed production (except in western Oregon, where it is only a minor pest). It is an annual parasitic plant that lives on alfalfa and other plants including commercial crops and weeds. Once germinated and attached to the host plant, dodder releases from its root and lives entirely on the host plant. Dodder has no leaves, and twists around the stems of host plants. Dodder suckers, or haustoria, penetrate the host tissue and withdraw nutrients for their own use. Dodder usually occurs in patchy spots in alfalfa fields. Seeds produced by dodder are similar in size and color as those of alfalfa, making it difficult to separate from alfalfa seed during the conditioning process. The process of cleaning weed seed from alfalfa seed typically reduces seed yield by 5 to 10%. Dodder produces 16,000 seeds per plant. The seed can remain dormant for five years and is viable for 60 years. Previous crops are the major source of dodder contamination. In California, dodder is a problem in tomatoes and safflower. In other areas of the west, dodder is a problem in carrot seed and other small-seeded vegetable seed crops (seed gets contaminated by dodder in these crops as in alfalfa and clover seed), and is notoriously prevalent in sugarbeets.

Common Mallow (*Malva neglecta*)
This weed is both biennial and perennial and has become more of a problem in alfalfa and irrigated clover seed in recent years. It is difficult to control, and its seed is a source of contamination. Not many chemical controls are effective on common mallow.

Yellow Starthistle (*Centaurea solstitialis*)
An extremely invasive weed that is difficult to control, yellow starthistle is not commonly found in alfalfa seed fields. It is of utmost importance that alfalfa seed growers be vigilant and not allow this weed to become established near production fields. Yellow starthistle is a long-lived winter annual that is a prolific seed producer. Seed output can be as high as 30,000 seeds per square meter. If a seed lot becomes contaminated with yellow starthistle, the seed cannot be cleaned out during conditioning. The size, shape, specific gravity, and seed coat characteristics make it almost indistinguishable from alfalfa seed as it moves through the conditioner's separation equipment. It can be separated using the magnetic separator, but the process is not very efficient and losses in both alfalfa seed quality and yield are high. Yellow starthistle has not yet been found in alfalfa seed fields in California, but it has the potential of becoming a huge problem if allowed in.

Prickly Lettuce (*Lactuca serriola*)
More difficult to control in new plantings than in established stands, prickly lettuce was once managed with 2-4 DB ester formulations, but is becoming more difficult to control now that the ester formulation is no longer available to growers.

White Cockle (*Silene alba*)
White cockle is a newly listed noxious weed in Washington State. It is an annual or short-lived perennial that spreads by seed and short rootstalks. Its seed is similar in size to

alfalfa, which makes it difficult to clean out of alfalfa seed. Infestation of farmland with white cockle would make it unsuitable for alfalfa seed production.

Yellow Nutsedge (*Cyperus esculentus*)
This aggressive perennial reproduces by seed, underground nutlets, and creeping rootstalks. Nutlets can remain viable for several years before producing new plants. Yellow nutsedge is a problem in numerous crops. The lack of suitable control measures in alfalfa and clover seed allows infested areas of yellow nutsedge to thrive and expand, resulting in greater competition to susceptible crops of many species (e.g., onions). Growers avoid planting to land infested with yellow nutsedge or use cultivation to manage it. Yellow nutsedge and white cockle are rarely, if ever, a problem in California alfalfa seed fields or in western Oregon clover seed fields.

Other Weeds
Damage to alfalfa seed by the lygus bug is accelerated by **wild mustards** (*Brassica kaber*) and **Russian thistle** (*Salsola iberica*). Additionally, armyworm moths (various species) are highly attracted to **common lambsquarters** (*Chenopodium album*) and **blue mustard** (*Chorispora tenella*), where they lay eggs. Checkered flower beetles *(Trichodes ornatus),* an important nest-predator of alfalfa leafcutting bees, can be suppressed by the control of weed pollen sources such as **mayweed** (*Anthemis cotula*), **wild carrot** (*Daucus carota*), **sunflower** (*Helianthus annus*), **knapweed** (*Acroptilon repens*), and **yarrow** (*Achillea millefolium*).

Certain weeds are problematic in western Oregon clover seed production that are not an issue in other areas. They include: annual and perennial ryegrass *(Lolim multiflorum* and *L. perenne*, respectively), groundsel (*Senecio vulgaris*), vetch (*Vicia sativa*) and wild carrot (*Daucus carota*).

<u>Cultural Control</u>: It is imperative to start alfalfa and clover seed production on a clean field. Field management practices start two years prior to planting by assessing the weed spectrum and initiating an appropriate weed control program. Cereals are the preferred crops to grow at this time because they allow the broadest range of herbicide choices for more complete weed control. However, if the field has a history of severe problems with cutworms or Columbia root-knot nematodes, wheat may not be a good rotational crop. If perennial grasses, such as quackgrass (*Elytrigia repens*), are present, a fall application of glyphosate (Roundup) or an equivalent is utilized. Weeds are most easily controlled as seedlings. If seedling control is not successful, survivors should be destroyed before harvest, since it is practically impossible to remove all weed seeds by cleaning. Volunteer alfalfa should be treated as a weed.

Proper seedbed preparation is important, which may include preplant herbicide use. At times, planting is delayed slightly to allow weed seeds to germinate. Some growers use shallow cultivation to stimulate weed seed germination so that germinating weeds can be destroyed before the alfalfa seed crop is planted.

In regions where fall planting is an option, this choice can aid in weed management because the crop will be established and growing vigorously before dodder and other winter annuals emerge. Weed screens are used on irrigation water to sieve many of the larger seeds out before irrigating.

Some growers control weeds on ditch banks and field borders to prevent weeds from moving into their fields. Cultivation between alfalfa rows and hand weeding are also effective measures.

Chemical Control: Many herbicides can be applied during establishment while others cannot be applied until the alfalfa has been established for one year or more.

Herbicides including benefin (Balan), EPTC (Eptam), and trifluralin (Treflan) are applied prior to planting and require incorporation into the soil. In certain circumstances (e.g., cold weather, drought stress) these herbicides can cause stunting of the new plants. Efficacy of soil-applied herbicides is dependant on soil moisture for activation and on the species of weeds that are present. Often, combinations of different herbicides are required for effective control of different weed species.

Once the seedlings have reached a certain growth stage, usually two trifoliate leaves, several postemergence herbicides can be applied including bromoxynil (Buctril), bentazon (Basagran), 2,4-DB (Butyrac), imazethapyr (Pursuit), and imazamox (Raptor). Buctril, Basagran, and Butyrac control only broadleaf weeds, while Pursuit and Raptor provide control of broadleaf and some grass weeds. Graminicides such as sethoxydim (Poast), fluazifop (Fusilade), clethodim (Select), and quizalofop (Assure II) can generally be applied any time the grass species being treated are at the stage specified on the label. The use of the postemergence broadleaf herbicides can be limited by restrictions on the label that require certain environmental conditions for application (e.g., Buctril should not be applied if the air temperatures are expected to exceed 70° F within three days following application) or by residual problems that restrict the crops that can be planted following the alfalfa seed crop (following Pursuit applications, sugarbeet can only be planted after 40 months and a successful bioassay). Some populations of various weed species have developed resistance to the family of herbicides that include Pursuit and Raptor. In the past 2,4-DB ester (Butoxone) was used for weed control during establishment. Butoxone is no longer produced and only the amine formulation of 2,4-DB (Butyrac) is available. The amine formulation is much less efficacious for weed control than the ester. Labeled rates of broadleaf herbicides such as 2,4 DB amine (Butyrac), bromoxynil (Buctril), and imazamox (Raptor) are weak on prickly lettuce. Postemergence herbicides are commonly combined to increase the level and the spectrum of weed control.

None of the preplant incorporated or postemergence products are effective for dodder control. Trifluralin (Treflan) has some activity on dodder but is only effective at rates that can be applied to an established alfalfa seed crop.

Critical Needs for Management of Weeds in Western U.S. Alfalfa and Clover Seed during Pre-Plant/Establishment

Research

- Look at new herbicides for alfalfa seed, red clover seed, and crimson clover seed, to get ahead of resistance (broadleaves and grasses).
- Research alternative control measures for prickly lettuce, yellow nutsedge, and white cockle.
- Determine effects of herbicides on seed quality and germination.
- Develop and research new herbicides for more complete weed control.
- Look at increasing the activity of the 2,4 D,B amine with surfactants.

Regulatory

- Pursue 2,4-D,B ester manufacturing and registration.
- Facilitate 3rd party registration of metolachlor (Dual) in Idaho.
- Regulate GMO stewardship issues (i.e., isolation, resistance management, export issues).

Education

- Educate seed growers and surrounding landowners about preventing yellow starthistle establishment.
- Train alfalfa and clover seed handlers and processors to comply with new non-food pesticide administrative rule (OR).
- Provide the results of herbicide research in extension publications for each state.

Diseases

Plant diseases are usually not as serious in alfalfa seed as in alfalfa hay production systems. Management for maximum seed yield involves thinner stands, fewer irrigations, and few harvest operations, all of which help reduce the onset and spread of disease. Alfalfa can tolerate stand reductions without significant seed yield reductions. However, serious problems may occur when disease organisms are carried on or in seed, or when rotational crops act as disease reservoirs.

Diseases are not problematic in irrigated clover seed. Neither seed treatments nor foliar fungicides are used. There are some minor disease issues, which are discussed below, in clover seed grown in western Oregon.

Verticillium Wilt *(Verticillium albo-atrum)*

Verticillium wilt is a serious disease of alfalfa seed. The causal fungus, *Verticillium albo-atrum,* can spread via infested seed and hay, soil, irrigation water, insects, machinery, and manure from animals that have eaten infected plants. The fungus does not survive well without a living host, although it can persist in dry hay and other plants and plant residue, especially in irrigated fields. This disease overwinters in soil, plant debris, and weeds. It is known that Verticillium can be carried within the seeds, but the extent of seed transmission is unknown. The disease causes wilting and chlorosis in upper leaves (flagging), although stems remain green. Defoliation and plant death follow. These plants also exhibit vascular discoloration. Verticillium wilt is more prevalent in cooler areas. It is not a serious problem in California alfalfa seed fields.

Cultural Control: Producers try to avoid disease problems by planting resistant varieties and certified seed. Planting alfalfa seed in areas known to have Verticillium wilt or other disease problems is avoided, especially when susceptible varieties are used. Most released varieties are resistant to Verticillium. High quality, clean seed is used. All machinery is cleaned and disinfected before leaving infected fields, especially in the case of cutter bars. Crop rotations with three to four years out of alfalfa should be effective in reducing disease incidence. Since several weeds including shepherdspurse (*Capsella bursa-pastoris*), buckhorn plantain (*Plantago lanceolata*), wild mustard (*Brassica kaber*), curly dock (*Rumex crispus*), and black nightshade (*Solanum nigrum*) are host to Verticillium, weed management during and between alfalfa plantings may help to control Verticillium wilt.

Chemical Control: No chemical treatments are available for Verticillium wilt.

Phytophthora Root Rot *(Phytophthora megasperma)*
Phytophthora root rot is a major cause of seedling death on newly established alfalfa seed fields and it causes a progressive decline in established stands. There has been much progress toward producing resistant varieties over the last 10 years. Phytophthora root rot is most damaging on susceptible cultivars and is favored where the soil remains wet due to high clay content, poor drainage, over-irrigation, or a combination of these factors. The fungus causes damping-off of seedlings, root rot, and rot of lower stems. It may also weaken plants, making them more susceptible to winter injury during severe winters. Symptoms of root rot are seen first in the above-ground parts of the plant as chlorosis, wilting, stunting, necrosis, collapse, and reduced yield. The affected roots, crown, or stem will have darkened lesions and cankers. Plant death may occur eventually, particularly in low areas of field where water stands for a longer period of time.

Cultural Control: Producers avoid planting alfalfa seed in areas known to have disease problems, especially when planting susceptible varieties. Excessive watering is avoided.

Chemical Control: Seed treatment with metalaxyl (Apron, Allegiance) will help control damping-off problems in seedling-stage alfalfa. No effective chemical controls are available for established stages.

Fusarium Wilt *(Fusarium oxysporum*)
This disease causes plants to be stunted. A red to reddish-brown discoloration inside the root becomes more severe as the stand matures and the disease progresses.

Cultural Control: Resistant varieties are the first line of defense. Most growers look for varieties that also have resistance to root-knot nematode to complement disease resistance. This reduces the exposure of the plant to the pathogen by nematode feeding on the roots.

Chemical Control: There are no effective chemical controls available.

Crown Rot Complex
Caused by a combination of various pathogens such as *Aphanomyces*, *Fusarium*, *Pythium*, *Rhizoctonia*, *Phoma,* and *Stagnospora*, crown root complex causes yield reduction and stunting. Symptoms include brown, necrotic, or dead tissue in the crown area of the plant, often enveloping the whole crown area. Despite this, the taproot may appear healthy.

Cultural Control: To reduce potential crown rot problems at this crop stage, growers use resistant varieties. Other practices are observed in later crop stages.

Chemical Control: There are no effective chemical controls available.

Anthracnose (*Colletotrichum trifolii; Kabatiella caulivora*, Northern race)
Anthracnose occurs most often in spring or fall and spreads rapidly under warm, wet conditions from spores produced on lower stems of infected plants. Early stages of the disease may appear as individual straw-colored stems on plants that display a curved top, often called a "shepherds crook." Diamond-shaped lesions occur on lower part of the stem. Advanced stages will be seen in the crown tissue as a dark black or coal color. Plant death usually occurs at this stage. Rainfed crimson and red clovers are susceptible to the northern race of anthracnose.

Cultural Control: To reduce potential anthracnose problems at this crop stage, producers use resistant varieties. Other practices are observed in later crop stages.

Chemical Control: There are no effective chemical controls available for alfalfa seed. All crimson and red clover seed planted in western Oregon is pre-treated with thiabendazole (Gustafson LSP) fungicide. No other controls are needed in clover seed for anthracnose.

Rhizoctonia *(Rhizoctonia solani)*
Rhizoctonia infection is encouraged by wet, humid conditions. Root damage generally occurs in warm soils or those conditions that favor high-temperature flooding injury (scald). Seedling damage may appear as damping off. Root damage in established fields occurs as elliptical lesions on the taproot at the point where the lateral roots emerge.

Cultural Control: Some varietal differences may occur, but no resistant varieties are available to growers. Growers minimize overwatering during the hot summer months to avoid Rhizoctonia infection.

Chemical Control: No economical chemical controls are available.

Stagonospora Root Rot *(Stagonospora meliloti)*
Stagonospora meliloti spores are produced on lower stems and leaves and are spread by irrigation water or rainwater to other plants. Root infection develops from stem and

crown infections. Evidence of the pathogen may be seen in cross sections of taproots or large stems as pockets of red-orange specks in the tissue. This pathogen is considered by some pathologists as one of the major causes of stand decline in California. It has also been identified as one of the causal agents of crown rot. Major effects of the pathogen are seen in the second and third years of stand.

Cultural Control: Resistant varieties are not known. No effective cultural control measures are known at this time.

Chemical Control: There are no effective chemical controls.

Sclerotinia/White Mold (*Sclerotinia trifoliorum*)
Although it is only a minor problem in alfalfa seed production, Sclerotinia is a common disease issue in crimson clover seed. Spores of this fungus are wind blown, and plants of all ages are susceptible to colonization, though the disease is more common earlier in the season. Diseased leaves fall and are covered with white fungus growth, allowing the disease to spread to the crown and roots. The majority of the damage is done during vegetative growth, but cultural control measures are taken prior to planting.

Cultural Control:
Crop rotation is a useful cultural control. Planting grass or grain can help reduce the inoculum. Controlling volunteer legumes is important.

Chemical Control:
No chemical control measures are taken at this crop stage. Control options are discussed in the subsequent crop stage, Vegetative Growth.

Minor Diseases
Many other diseases occur routinely in alfalfa seeds fields. For the most part, the following diseases (listed with their associated pathogens) are not considered a major limiting factor to production. However, they may periodically be a serious problem.

Alfalfa dwarf/Pierce's disease	*Xylella fastidiosa/Vitis vinifera*
Alfalfa mosaic virus	Alfalfa mosaic virus
Alfalfa wart	*Urophlytis alfalfa*
Aphanomyces root rot	*Aphanomyces euteiches*
Common leaf spot	*Pseudopeziza* spp.
Downy mildew	*Peronospora trifoliorum*
Lepto leaf spot	*Leptosphaerulina briosiana*
Rust	*Uromyces striatus*
Spring black stem	*Phoma medicaginis*
Stemphylium leaf spot	*Stemphylium botryosum*
Summer black stem	*Cercospora medicaginis*
Witches broom	various

Critical Needs for Management of Diseases in Western U.S. Alfalfa and Clover Seed during Pre-Plant/Establishment

Research

- Develop seed treatment to control damping off.
- Develop new control measures for seedborne diseases.
- Discover the relationship of clover root cucurlio and Phytophthora.
- Develop commercially viable seed crop varieties to continue resistance management.
- Develop disease-resistant varieties.

Regulatory

- Facilitate registration of new seed treatments and/or field treatments for damping off diseases.
- Facilitate labels for the new seed treatments.

Education

- Produce extension publications addressing field selection and land preparation toward stand establishment for seed production.

Insects

Alfalfa and clover seed growers scout their fields to quantify and identify insect pests and to determine which control measures are needed. Chemical controls registered for use on alfalfa seed are presented in Table 3.

Clover Root Curculio *(Sitona hispidula)*

The clover root curculio (CRC) is an important weevil affecting alfalfa and clover root systems in the Pacific Northwest, primarily on forage alfalfa and primarily in Idaho. Adult clover root curculio weevils resemble alfalfa weevils. Larvae are white grubs and are normally found in the soil close to alfalfa root systems. Adults become active in the spring and deposit eggs on the soil surface or on the undersides of leaves of host plants. By May or early June, newly hatched larvae move into the soil where they begin to feed on roots.

Damage: Damage by this pest is not widespread, but in some areas of severe infestation, significant losses of quality, stand, and yield may occur. Adults feed on foliage, leaving semicircular holes around the leaf margins. This damage can be insignificant on established stands, but very injurious to new seedings. Larval feeding on plant crowns and roots is the most important damage caused by this pest. Larvae feed externally on the roots, causing scoring or girdling. This damage allows the entry of disease pathogens, specifically Phythopthora root rot.

Cultural Control: An important cultural control for CRC is crop rotation to non-susceptible species. Susceptible species include legumes such as soybeans and lespedeza, and some grasses such as Kentucky bluegrass. A rotation including potatoes or sugarbeets will help eliminate the pest. Adequate fertilizer and soil moisture monitoring are important defenses against this insect. Late fall plowing will expose the beetles and larvae to killing conditions and natural predators. Resistant varieties are an important tool against CRC. Lahontan variety has shown resistance to CRC.

<u>Biological Control</u>: None known.

<u>Chemical Control</u>: Soil pesticides applied for wireworms, nematodes, and root maggots during non-alfalfa years may help prevent CRC buildup and damage when alfalfa is re-planted. Soil fumigation can be efficacious but is not economical during the alfalfa crop. Foliar sprays applied in the spring for alfalfa weevil will kill many adults and exposed larvae, but larvae in the soil are unaffected. Lambda-cyhalothrin (Warrior) is registered for CRC control in alfalfa seed, but is not effective.

Cutworms *(Peridroma, Euxoa, Agrotis, Feltia, Amathes,* and *Scotogramma* spp.)
Economically important species of cutworm include variegated (*Peridroma saucia),* redbacked *(Euxoa ochrogaster),* army *(E. auxiliaries),* darksided *(E. messoria),* pale western *(Agrotis orthogonia),* dingy *(Feltia ducens),* spotted *(Amathes c-nigrum),* and clover (*Scotogramma trifolii*). Larva is the damaging stage of these pests, but the biology of individual cutworms species varies. Overwintering occurs in egg through larval stages and development varies based upon species and region, therefore time periods of cutworm damage vary from region to region. See Seasonal Pest Occurrence tables, Appendix B, for typical damage periods in the various growing regions. Generally speaking, warmer weather during the spring favors alfalfa and clover growth and development and shortens the period of crop susceptibility to cutworm feeding while cooler spring temperatures slow alfalfa growth and tend to favor cutworm development and damage. Cutworm outbreaks are sporadic, often separated by many years in which there is little damage.

<u>Damage</u>: Cutworm species typically feed at night, withdrawing below ground during the day, making them difficult and time-consuming to monitor. Distinctions should be made between climbing species (army cutworm, variegated, and darksided) that defoliate plants and more damaging ground-dwelling species (pale western, dingy) that clip stems. Damaging species are typically active and feeding during the spring and do not pose problems during later phenological stages. Ground-dwelling species feed at or below ground on crown and roots, in severe cases thinning stands and reducing seed yields. Feeding occurs throughout the spring, depending on the activity of each species, until pupation in early summer. Army cutworms, however, can inflict damage to the crop during warm, open fall weather, especially in the southern regions.

<u>Cultural Control</u>: If cutworms are a serious problem, seed growers avoid rotations from winter wheat or grass hay to alfalfa, as winter wheat is another early-spring host of cutworm. Adequate irrigation and fertilization of new stands help plants past the most vulnerable phase for cutworm damage.

Biological Control: No biological control agents are known to affect this pest. Predators, parasites, and diseases usually keep cutworm populations in check, but when these natural regulators fail, populations can increase dramatically and cause damage to localized alfalfa seed fields. Soil moisture promotes fungal pathogens that kill many larvae in wet years.

Chemical Control: Cutworm control is difficult. The weather is often cold when cutworms are actively feeding on the roots and ground-dwelling species do not feed above ground. Therefore, they will not come into contact with the chemical treatment. Some growers irrigate before using chemical control methods in order to drive the cutworms out of the soil. Also, early evening or morning applications of chemicals, when the cutworms are more likely to be on foliage or above ground, are more effective than daytime treatments. Growers in Utah use permethrin products (Ambush, Pounce) for cutworm and armyworm control. See Table 3 for additional chemical information.

Alfalfa Seed Chalcid *(Bruchophagus roddi)*
Alfalfa seed chalcid larvae overwinter inside the seed and emerge late in the following spring. Adults emerging in May and June lay eggs in seedpods. When they hatch, they infest developing seed. Chalcids select developing alfalfa seedpods wherever they are available, with the most common seed source being plants growing outside of fields. Several generations of the chalcid are completed each year, with the levels of infestation in seed becoming progressively higher as chalcid populations increase in mid- and late summer. Research has shown that up to 80% of seed harvested in September may be infested, absent any cultural control.

Damage: Young seeds infested with chalcid larvae are plump and develop a premature light brown color, in contrast to uninfested seeds, which have a healthy green appearance at this stage of development. Infested seeds will not develop. Seed loss can be as high as 15%.

Cultural Control: Where alfalfa seed has been grown previously and a new seed crop is scheduled to be planted, growers burn or cultivate pre-plant (i.e., post-harvest) to prevent seed chalcid infestation. Cultural practices such as harrowing or discing to bury chalcid-infested seed 1 inch deep followed by irrigation are effective in preventing adults from emerging. Infested seed should be cleaned and the cleaning screens destroyed. Throughout the crop cycle, mowing of volunteer alfalfa and other alternate host plants outside the seed crop helps to keep chalcid populations down. It is important that a cultural control program for the seed chalcid be initiated prior to planting, as this species cannot be controlled by insecticide applications during production of the seed crop.

Chemical Control: No chemical controls are available.

Alfalfa Weevil *(Hypera postica)*
Alfalfa weevil is the most destructive insect of forage alfalfa in the intermountain western region of the United States and also infests alfalfa grown for seed**.** It is not a problem in California alfalfa seed production. Adults overwinter in alfalfa crowns, plant debris, and

adjoining protected areas, emerging as temperatures warm to begin feeding and mating. The damaging larvae feed on developing leaves within plant terminals and on expanded leaves. Terminals can be damaged and even killed by alfalfa weevil larvae feeding, damaging or delaying flower formation and therefore seed set. However, management of alfalfa weevil for seed producers is different than for forage producers because seed producers need to protect pollinators. Pre-bloom sprays typically target alfalfa weevil along with lygus bug (discussed in detail in the following crop-stage section) and pea aphid.

Damage: Early in the spring, adult females chew holes in alfalfa stems, laying 5 to 20 eggs in each hole. The tiny larvae hatch and migrate to the plant terminals where they feed on the growing stem and expanding leaves. Older larvae feed mostly on open leaflets, but also on terminal buds. Larvae complete development in 3 to 4 weeks. Damaging larval infestations slow plant growth, skeletonize leaves, and destroy buds. High larval densities result in dried foliage and a grayish or frosted appearance, or complete defoliation. Weevils are most damaging in areas with short growing seasons where the crop is not clipped prior to starting a seed crop.

Cultural Control: Alfalfa weevil is not usually a serious pest of newly established plantings. Proper crop take-out, rotation, and seeding practices greatly reduce populations of overwintering adults in both fall and spring plantings. In addition, most alfalfa weevil adults will have migrated into established alfalfa stands before seedlings emerge in spring-seeded stands. Early cutting is used to control alfalfa weevils in forage production in Montana. Varieties with resistance to alfalfa weevil are available, but generally only forage growers can chose varieties according to pest resistance. The option to choose a particular variety based on pest resistance characteristics is not generally available to alfalfa seed producers, because they are required to grow the varieties for which they have contracts. Alfalfa seed growers only have the choice to accept or decline a contract to produce a specific variety.

Biological Control: Several species of parasitic wasps have been released and recovered in most western states and are among the most specific and effective biological agents for weevil control. The parasitic wasp *Bathyplectes curculionis* is present throughout the range of the alfalfa weevil.

Several general predators including ladybird beetles, lacewings, and damsel bugs may prey on alfalfa weevil larvae in the absence of aphids, their preferred prey. Limiting insecticide use to the minimum necessary encourages their activity by conserving their natural populations. As biological control has limited effectiveness, most growers apply insecticides.

Chemical Control: Most growers monitor regularly for alfalfa weevil, employing chemical measures when economic thresholds are exceeded. See Table 3 for insecticides used.

Egyptian Alfalfa Weevil *(Hypera brunneipennis)*
Egyptian alfalfa weevil is a pest in alfalfa fields in California; it is not found in the Pacific Northwest or the intermountain states. It is generally not a problem in new plantings. In established stands, depending on the timing of the infestation, populations are controlled either through clipping or a chemical application.

Pea Leaf Weevil *(Sitona lineatus)*
The adult pea leaf weevil is slender, gray-brown, approximately 5 cm long, and has a short snout and three rows of light colored scales on the thorax. Larvae are legless white grubs approximately 6-7 cm long with dark brown heads. There is one generation per year.

Damage: Adults emerge from overwintering sites in the spring (March) and feed by chewing large semicircular notches from alfalfa leaves. Seedlings are very susceptible to injury and may be killed if the growing tip is damaged. Even small populations can cause severe stand reduction. Damage may also occur later in the season by larvae feeding on the roots of plants, particularly on root nodules. However, older plants are much less likely to suffer significant injury.

Cultural Control: Fields are monitored for adults in March and April. Economic impacts will occur if there is more than 25% injury on the terminal leaves of seedling plants.

Biological Control: Overwintering adults may be killed by the naturally occurring fungus *Beauvaria bassiana*, but mortality may be too low to reduce weevil numbers to below damaging levels.

Chemical Control: There are no registered pesticides for this pest. When fields are treated for alfalfa weevil or pea aphid, however, pea leaf weevils are controlled as well.

Aphids *(Therioaphis Acyrthosiphon, Macrosiphum,* and *Aphis* spp.)
Non-dormant alfalfa varieties are more likely to have higher levels of aphid resistance than dormant varieties. For that reason, aphids as a group are second only to lygus bugs in terms of economic importance in seed growing areas where production of dormant seed is dominant. The more central and southern regions of California, where production of non-dormant varieties is dominant, aphids as a group are less economically important. In red clover seed production, where lygus bugs are not a problem, pea aphids are the most economically important insect pest.

All aphid species have piercing-sucking mouthparts, which they use to suck plant sap and cell contents from vegetative plant parts. They do not directly damage seed-producing structures. Aphids also produce a sugary, sticky material called “honeydew” which is visible on plants in moderate to severe infestations and can also contribute to the presence of sooty mold.

Aphids reproduce parthogenetically, each female giving birth to 50 to 100 live young at the rate of 6 to 7 per day. Multiple aphid generations can occur each year depending on weather conditions, and aphid populations can increase quite rapidly. Local, high-density populations induce the formation of winged forms, which are able to migrate within and between fields.

It is important to distinguish among the aphid species as their damage potential and treatment regimen differ.

Spotted alfalfa aphids *(Therioaphis maculata*) prefer hot, dry conditions and generally are a problem on rain-fed crops, later cuttings, and late summer plantings, although they have been found damaging dryland alfalfa.

A complex including the pea aphid *(Acyrthosiphon pisum)*, alfalfa aphid *(Macrosiphum creelii),* and blue alfalfa aphid *(Acyrthosiphon kondoi)* combines to cause damage in much of the western alfalfa seed-producing region. The pea aphid is found in all alfalfa seed-producing regions, whereas the alfalfa aphid has a more northern distribution including Washington, Oregon, Idaho, and occasionally in Montana, but not Nevada or Utah. The pea and alfalfa aphids cannot be distinguished in the field and the damage they cause is similar. Both are approximately 8 mm long and may be green, yellow or pink. Overwintering females give birth to live young at the rate of 5 to 7 per day. The blue alfalfa aphid is bluish-green but difficult to separate from the pea aphid in the field. It is established in all western alfalfa seed growing regions. Blue alfalfa aphids feed mainly on the alfalfa buds, forming tight colonies on the elongating stems. Pea aphids and blue alfalfa aphids prefer cool, dry conditions, although blue alfalfa aphids are less tolerant to heat. Both are problems during spring seedling establishment. Blue alfalfa aphids are more likely to exist in damaging numbers in the spring to early summer and fall. Pea aphids tend to congregate along the stems, terminal shoots, and leaves while the blue alfalfa aphid prefers the growing point and buds.

Recently, the cowpea aphid *(Aphis craccivora*) has become more prevalent in alfalfa fields in the alfalfa seed production areas of California. It has not been a problem in alfalfa seed produced in the Pacific Northwest and intermountain regions. These aphids are shiny black, 2 to 2.5 mm long, with the first half of the antennae and all of the legs pale yellow or white. Immature forms may be lime green. Cowpea aphids prefer to feed on young terminal growth, but can be found infesting leaves, blooms, and stems.

Damage: The spotted alfalfa aphid and blue alfalfa aphid both secrete a toxin while feeding that can cause considerable injury including severe stunting and/or considerable yellowing (chlorosis) of leaves. Fields heavily infested with spotted alfalfa aphid will appear dried; plants will eventually die if left untreated. Newly established plantings are particularly vulnerable. Heavy infestations of pea, alfalfa, and/or cowpea aphid can cause alfalfa plants to wilt and yellow. Large pea aphid populations (1000 or more per sweep) can result in bloom drop. Severe stunting and plant death have been observed in conjunction with the presence of pea and alfalfa aphid, but these impacts are not common. Cowpea aphid infestation is associated with severe stunting, twisted leaves, and deformed alfalfa plants. Cowpea aphid is also an efficient vector of several important virus diseases of alfalfa including alfalfa mosaic virus. All aphids produce honeydew, but the cowpea aphid, spotted alfalfa aphid, and blue alfalfa aphid produce copious quantities; honeydew produced by the cowpea and spotted aphid in particularly contribute to the formation of sooty mold. Large aphid populations may stunt plants, cause foliage to wilt and/or yellow or may prevent or delay flowering. Any delay in flowering can compromise seed maturation and also bee reproduction. If damage is severe and prolonged, the leaves may drop from severely infested plants.

Cultural Control: Newly planted fields are most susceptible to aphid damage. Therefore, efforts to establish a healthy, vigorous, mature stand are an effective strategy for minimizing aphid damage.

Biological Control**:** Aphids are attacked by a diverse community of natural enemies, including specialist parasitoid wasps, damsel bugs, minute pirate bugs, lady beetles, ground beetles, syrphid fly larvae, lacewing larvae, and web-building spiders. Aphid "mummies" also are common in cowpea and pea aphid colonies. These swollen, tan-to-copper aphid skins are the result of parasitism, suggesting that natural control is at work. However, predators cannot exist without insect prey upon which to feed. Low to moderate populations of aphids, except spotted alfalfa aphids, are tolerated as they help to maintain populations of natural enemies that can significantly reduce numbers of aphids and other alfalfa seed pests. Generalist predators have an immediate impact on reducing aphid populations, but over time the aphid populations still increase. Parasitoids have very little impact on aphids early in the season, but over time they do cause aphid populations to decline.

Chemical Control: Treatments are justified when aphids have exceeded established economic thresholds. The most effective chemical control for spotted alfalfa aphid is endosulfan (Endosulfan, Thiodan). Growers in the Warden area of Washington State may use phosmet (Imidan) for control of pea aphids. However, most growers in the west (excluding California) use pirimicarb (Pirimor) for control of pea aphids, which is a key element in their IPM programs. Chemical control options are listed in Table 3.

Slugs (various species)
These land mollusks feed on rainfed red and crimson clover, damaging roots, crowns, leaves and fruit.

Chemical Control:
Metaldehyde baits (several brands) are the only control measure available for slugs. They are applied after the rain, when dry days are expected. However, on occasion, baits are washed away by unexpected rains. They are most effective when applied after the first good rains, before mature slugs begin laying eggs, because the bait is not as effective on young slugs. Baits are used throughout the establishment and vegetative growth stages.

Table 3: Insecticides registered for use on alfalfa seed or alfalfa hay (allowed for use on alfalfa seed through non-food designation). "Pre," "during," and "post" refer to period in bloom cycle the insecticide is applied. Not all insect pests of alfalfa seed are listed; see also Insect Management in Alfalfa and Clover Seed table in Appendix C, Efficacy Tables.

Management Tool	Lygus Bugs	Spotted Alfalfa Aphid	Other Aphids	Alfalfa Weevil	Grasshoppers	Cutworms	Armyworms	Spider Mites
abamectin (Agri-Mek) SLN (ID, OR, WA, NV)								X
bifenthrin (Capture) SLN (ID, OR, WA, NV, MT, UT)	pre or during			pre				X
carbofuran (Furadan) (not in CA)			pre					
chlorpyrifos (Lorsban)	X	pre				X		
diflubenzuron (Dimilin) SLN (ID, OR, NV, WA)					during			
dimethoate (Dimethoate)	pre or post as a clean-up spray							
endosulfan (Endosulfan, Phaser, Thiodan) (CA) SLN (ID, OR, WA)	pre	X						
formetanate hydrochloride (Carzol)	X							
hexythiazox (Onager) SLN (ID, OR, WA, NV, MT)								X
lambda-cyhalothrin (Warrior)	pre or during			pre or post	X	X	X	suppres-sion
malathion (Malathion)			pre				alkalai bees only	
methamidophos (Monitor) (SLN)	CA only							
methidathion (Supracide) SLN (ID, OR, NV, MT, UT, WY)	pre		pre					
methomyl (Lannate)	X	X	X	X			X	
methyl parathion (Penncap-M, Methyl Parathion)	pre		pre	larval control				
naled (Dibrom) SLN (ID, OR, NV, MT)	pre or during							
oxymedeton-methyl (MSR)	early instars	X	X					X
phosmet (Imidan)			pea only	X				
pirimicarb (Pirimor) (not CA)			X					
permethrin (Ambush, Pounce)	pre	pre or during		pre		X	X	
propargite (Comite) SLN (ID, OR, WA, NV, MT)								X
pymetrizone (Fulfill) SLN (ID, OR, WA, NV, MT, UT)			pre or during					
Sulfur DF								X
zeta-cypermethrin (Mustang)	pre							

Critical Needs for Management of Insects in Western U.S. Alfalfa and Clover Seed during Pre-Plant/Establishment

Research

- Understand aphid complex life cycle and develop economic thresholds, management options and timing recommendations.
- Develop standard (more stringent) tests for aphid resistance classification.
- Develop resistant germplasm for lygus and aphids, either through biotechnology or traditional breeding techniques.
- Investigate efficacy of chemical controls on alfalfa seed chalcid.
- Find new, cost effective chemical control for clover root curculio.
- Investigate cutworm species complex, life cycle, economic threshold evaluation and management options and timing.
- Evaluate aphid species complex and composition, economic threshold, and management options.
- Improve management options that consider reducing negative effects on pollinators
- Develop alternatives to synthetic pyrethroids.
- Test insecticides for efficacy on pea leaf weevil.

Regulatory

- Retain registration of pirimicarb (Pirimor) for control of aphids.

Education

- Educate growers about cutworm complex lifecycle, economic threshold and management options and timing.

Vertebrates

Meadow voles (*Microtus* spp.) and **field mice** have been a problem in alfalfa in Idaho during the past several years. The voles move out of the desert lands into the green crops, devastating seedling plants. Meadow voles can also be a problem in western Oregon red clover seed production. Growers in Idaho have used zinc phosphide under a Section 18 emergency exemption to control the voles for the past several years. EPA issued a tolerance for zinc phosphide on alfalfa in October 2003 and subsequently approved the registration of a zinc phosphide pellet product called Prozap. USDA-APHIS has developed a zinc-phosphide-impregnated wheat-seed product for use as bait against rodents in alfalfa, but has not yet registered this product.

Gophers can be a problem, especially in fields under center pivot irrigation. Baits and traps can be used, including zinc phosphide, gopher bombs, and underground strychnine baits. Some growers are planting sudan grass, then discing it in, for control of gophers.

Horned larks are a serious pest of a number of field and vegetable crops grown throughout California. Resident populations of horned larks are found in the stubble, grass, and fallow areas near cultivated fields. Damage usually begins as the plants first emerge from the soil. Horned larks nip off parts of the young seedlings or they may pull the entire plant from the soil. Damage usually stops when seedlings grow to a height of 3 to 4 inches.

Canada geese, a protected bird species, commonly devastate clover seed fields in western Oregon. There are no control measures, although authorities have allowed growers to shoot one or two geese, and leave them laying in the clover seed field to detract other geese from landing. However, after a week, the carcasses are eaten by other animals and geese begin landing once again.

VEGETATIVE GROWTH

As mentioned in the previous section, most alfalfa and clover seed is grown as a perennial crop. The primary exception is in western Oregon where crimson clover is always an annual crop. In many regions, the first year is devoted to stand establishment; seed is not harvested until the second and subsequent years. This and the following several crop-stage sections of this document (Pollination and Seed Set, Seed Maturation, Harvest, Post-Harvest, and Dormancy) address pest management during the seed crop's production years, i.e., years in which seed is harvested (typically year 2 to year 4 or 5 of the crop). This section, Vegetative Growth, addresses pest management from the emergence of the alfalfa/clover crop through the pollination/seed-set stage during production (seed harvest) years.

Once alfalfa and clover seed stands are established, weed and insect control programs are conducted on an annual basis. Fertilization (pending results of soil and plant tissue analyses), irrigation, and thinning are also practiced during the years following establishment to promote a healthy stand. Clover seed is not thinned. Alfalfa seed in California, as well as rainfed clover seed is rarely, if ever, fertilized.

Stand density is an important factor in crop vigor. While no single method is standard, cross-cultivating is frequently used. Thinning usually takes place in the spring, as fall thinning can lead to increased winter injury. Often more than one thinning operation is necessary.

Established alfalfa and clover seed crops in most of the regions represented in this document are flailed in spring in a process known (depending on region) as clip-back or set-back. Clip-back is called "flailing" in western Oregon because the clover plant is cut and used for forage. Timing varies greatly throughout the region; it can occur as early as the first part of April on alfalfa seed in the Central San Joaquin Valley and as late as June for clover seed in western Oregon. The purpose of clip-back/set-back is to encourage plants to come into bloom uniformly and to synchronize bloom with the period in the season where pollinators are most active. The field should be coming into bloom at the time of clip-back/set-back, or initial seed set may be reduced due to the negative impact on root reserves. The clipping may be a forage harvest (western Oregon only), chopping, or chemical clipping, depending on grower preference and previous pesticide use in the field. These operations can be followed by light harrowing and row cultivation to control weeds and volunteer alfalfa from the previous harvest. Following clip-back/set-back, re-growth is initiated and the plant blooms approximately 35 to 45 days later. Spring clipping also removes growth that has overwintered and cleans up the field for herbicide applications. Nevada and Wyoming growers, due to high elevation and shorter growing season, do not practice clip-back/set-back. Clip-back is rarely done in irrigated clover seed.

Spring burning for pest management may control some foliar diseases and some insects that may have overwintered. Walla Walla Valley is the only region that burns in the spring. Many states are aggressively moving away from burning.

Nematodes

The five most important nematodes at this stage are the northern root-knot nematode (*Meloidogyne hapla*) Colombia root-knot nematode (*Meloidogyne chitwoodi*), southern root-knot nematode (*M. incognita*), lesion nematode (*Pratylenchus penetrans*) and the alfalfa stem nematode (*Ditylenchus dipsaci*). Nematode activity can result in stand reduction, weakened plants, chlorotic patches within the field, and increased plant susceptibility to diseases. Individual nematode species and the characteristics of the damage each inflicts are described in greater detail in the previous (Pre-Plant/Establishment) section.

Critical Needs for Management of Nematodes in Western U.S. Alfalfa and Clover Seed during Vegetative Growth

Research, Regulatory, Education

- Same as those listed under Pre-Plant/Establishment section.

Weeds

Early-season weed control is accomplished primarily through the soil-active herbicides discussed in the previous (Pre-Plant/Establishment) section. A few soil-active herbicides can be used during the vegetative growth plant stage, but most post-emergence herbicides have strict stipulations about the size of the alfalfa seed crop when the herbicide application is made. Between thinning and clip-back/set-back, soil-active herbicides such as ethalfluralin (Sonalan), pendimethalin (Prowl), and trifluralin (Treflan) are sometimes applied and incorporated.

Since soil-active herbicides are mainly germination inhibitors, they have no activity on emerged weeds. Weeds that cannot be controlled by herbicides may be removed by hand during this period, especially during the first production year.

Dodder management is critical in the vegetative growth period, as no products will control dodder once it has germinated and become attached to the alfalfa. Pre-emergence herbicides for dodder control are applied at this time. Pendimethalin (Prowl) is the most commonly used and most efficacious treatment, but even at maximum rate does not completely control dodder. Trifluralin (Treflan) is sometimes used in California in a split application. A biological control product called Smolder (a fungus, *Alternaria destruens)* has been tested against dodder but is not effective in alfalfa seed because it requires a humid environment and the alfalfa-seed-growing regions are dry in nature.

Critical Needs for Management of Weeds in Western U.S. Alfalfa and Clover Seed Vegetative Growth

Research

- Research new control methods for dodder, including post-emergence herbicides.
- Research new control methods for Canada thistle.
- Develop new biocontrols for dodder management.
- Develop growing degree day (GDD) models for dodder emergence in growing regions beyond California.

Regulatory

- Work with state regulatory agencies to allow spot burning in an integrated dodder control program (needed in California, needs to be maintained in other regions).
- Provide improved clarity on herbicide application issue around salmon-bearing streams. EPA needs information to support approved regulatory labels.

Education

- Educate growers about the utility and delivery of GDD models.
- Educate the public and regulatory agencies about the benefits of spot burning.

Diseases

See general Disease comments in previous crop-stage section. **Sclerotinia root rot** is an increasing problem in western Oregon, Montana, and the Columbia Basin. Spring and summer **black stem** may occasionally pose a serious problem.

Sclerotinia/White Mold (*Sclerotinia trifoliorum*)
Sclerotinia is the primary disease concern of crimson clover seed growers. The majority of the damage is done at this crop stage, but cultural control measures are taken prior to planting.

Chemical Control:
Foliar sprays of ipridione (Rovral) are used to manage Sclerotinia. Rovral is used under a 24c exemption and is only registered in Oregon, and only for crimson clover. Infection of crimson clover (which is always fall planted) can begin as early as January, and may continue until harvest. However, only two applications of Rovral are permitted per season, and these usually begin early.

Crown Root Complex
The disease is most severe when the plant crowns are damaged in some way (e.g., mechanical impact, insects, nematodes, frost, extensive grazing) that allows the pathogen access to crown tissue.

Cultural Control:
Producers avoid mechanical injury to the crown as much as possible through field operations at this and later crop stages.

Critical Needs for Management of Diseases in Western U.S. Alfalfa and Clover Seed Vegetative Growth

Research

- Develop new control measures for Sclerotinia.
- Develop new control measures for Verticillium wilt.
- Research and develop new fungicide modes of action for resistance management.
- Research new control measures for spring and summer black stem.

Regulatory

- Improve certification standards for phytosanitary field testing of seed exports leaving the U.S.
- Improve and expedite methods for obtaining phytosanitary certificates for seed shipments internationally.

Education

- Provide extension publications on management of alfalfa diseases in seed production.

Insects

Refer to Table 3 in the previous section and the Insect Management efficacy table toward the end of the document for specific insecticide information.

Clover Root/Crown Borer (*Hylastinus obscurus*)
A red clover stand in the Willamette Valley usually lasts for only one or two seed crops because of clover root/crown borer activity; it is the limiting factor in red clover seed production in western Oregon..

Damage: The adult lays eggs in the crown of the plant. The larvae mine out channels in the roots, which then become a site for infection with root rot fungus (*Fusarium solani*). Plants are weakened and the seed yield drops in the second year. A third year of seed production is not economical.

Control: There is no control for clover root borer other than rotation.

Lygus Bugs *(Lygus* spp.)
Lygus bugs, found throughout the western United States, are the most important pest of alfalfa seed. In turn, alfalfa grown for forage or seed is probably the single most important crop species in terms of its impact on lygus bug population development. Alfalfa is both a major overwintering site and an important host for early season lygus population development. Lygus bugs are not a problem in clover seed production.

In most areas of the west (with the exception of the southwest, where they may be reproductively active the entire year), lygus bugs enter a state of reproductive diapause during the winter. They overwinter as adults in annual and perennial plants and plant debris in nonagricultural areas, in weedy areas in and around agricultural fields, and in some overwintering crops. Populations build to large numbers beginning in early spring as overwintering adults begin feeding and ovipositing on overwintering hosts.

Adult lygus bugs are highly mobile. Populations resulting from buildup on spring hosts move readily to summer crop hosts as spring hosts mature and senesce, then move to new crops hosts throughout the summer and fall as harvest occurs or as individual crops mature and dry.

Damage: Lygus bugs feed by the lacerate-and-flush method, injecting salivary fluid containing pectinases and amylases that aid in the digestion of cellular material. Feeding by lygus bugs can reduce both quality and quantity of yield of agricultural crops through the combined action of secreted enzymes and mechanical injury from probing. Lygus adults and nymphs feed on alfalfa, but most economic damage to alfalfa seed is caused by late (fourth and fifth) instar nymphs and adults feeding on developing alfalfa flower buds, flowers, and immature seed pods and seeds. Lygus bug feeding on developing flower buds causes plant stunting and “blasting” of flower buds in which buds turn white and fail to develop. Feeding on flowers and immature seed pods can cause them to fall without forming pods. Immature seeds fed upon by lygus bugs collapse or shrink, darken, and lose quality and viability. Yield losses from lygus bug feeding in the absence of control ranges from 50% to over 90%.

Cultural Control: Because of the wide host range of lygus bugs, weeds can be an important source of lygus bug infestations. Suppression of weed hosts in and around alfalfa seed fields is an important cultural practice that can help to slow lygus bug population build-up. Alternative lygus bug host plants include mustards, common lambsquarters, kochia, Russian knapweed, and Russian thistle. In California, strip planting other crops (e.g., safflower, alfalfa hay) for the purpose of providing a refuge for pollinators or establishing a trap crop for lygus bugs is an option, but has not been successful in large-scale trials. Safflower is a minor crop with few, if any, registered materials that effectively control lygus bugs. The number of acres required to use alfalfa hay as a trap crop make it an uneconomical option. Both practices created non-uniformity of soils across a production unit that made it difficult to manage subsequent crops.

Biological Control: Development of commercially effective biological lygus bug control has largely focused on preserving natural enemies that exist in alfalfa seed fields through the use of selective insecticides and through selective timing of pesticide applications. Several predator species such as lady beetles, green lacewing larvae, and syrphid fly larvae may be present in alfalfa seed fields but feed mainly on aphids. Minute pirate bugs are often present, but prefer thrips. Big-eyed bugs and damsel bugs are usually the most effective predators of lygus bugs. Therefore lygus biological control efforts focus on conservation of big-eyed bugs and damsel bugs. Big-eyed bugs are usually more abundant than damsel bugs, but damsel bugs show a greater preference for lygus bugs.

Parasitism of lygus bug nymphs and adults has been described in several Pacific Northwest studies indicating that parasitism of lygus bug nymphs by native parasitic wasps in the genus *Peristenus* and perhaps other species can have an important impact on lygus bug numbers in alfalfa seed, alfalfa, and perhaps other crops. A great deal of the information on the biology of *P. howardi,* the most important parasite of lygus nymphs identified so far in the western United States, comes from collections made at a few locations in Washington and Idaho. Samples collected from various weed and crop hosts of lygus bugs indicate that *P. howardi* may be an important component of an integrated lygus management program. Research on this parasite is currently underway at a number of laboratories in the western United States.

<u>Chemical Control</u>: Economic thresholds have been established and are commonly used in the western alfalfa seed-producing states. When lygus bugs exceed thresholds during the prebloom and bloom period, one or more pesticide applications are required to control them. A degree-day model for lygus bugs has been developed that helps to time field scouting activities and to predict lygus bug outbreaks.
Insecticide applications are used as part of an integrated management plan to control lygus bugs. A number of compounds are available but several factors influence the choice and timing of pesticides, including:

- number and life stages of lygus bugs present,
- number and stages of other pests present,
- species and abundance of natural enemies (of lygus bugs and other pests),
- condition and phenological stage of the crop,
- pesticide resistance management considerations, and
- presence of pollinators.

Nearly all of the compounds registered for lygus bug control will also kill pollinators by direct contact at field rates. Pollinator protection is a primary concern. In general, growers attempt to make applications for control of lygus bugs before and/or after the majority of the seed has been set by pollinators. When applications must be made during pollination, special precautions are observed. The first application is made on a warm day, based on thresholds. Natural enemy populations are factored into the threshold calculations for lygus (i.e., high natural enemy counts might discourage a grower from applying chemical controls for lygus at threshold levels).

The first application is usually a tank mix for lygus and aphid control. Insecticides for first application are chosen for long residual control in hopes that additional applications are not needed before bloom. Natural enemy populations are low in the early vegetative stage, therefore impacts on natural enemies from the first application are minimal. If the economic threshold for lygus is exceeded again pre-bloom, an additional tank mix will be applied. To manage resistance, insecticides used in the second tank mix will be selected so the mode of action is different from the mode of action of the insecticide used in the first application. (Note that insecticide resistance in lygus has been slower to develop in Montana alfalfa seed, where production is distributed throughout the state rather than concentrated in smaller, more intensive regions.) The insecticide selection for the second tank mix is also influenced by the presence of other pests and natural enemies, which are more numerous by the time a second application occurs. In California and the Columbia Basin, no insecticide is applied until just prior to putting bees in the field. This application is timed so that as soon as pollinators are necessary, it is safe for them to be put in the field.

Growers ***always*** try to avoid spraying while the bees are in the field. To protect pollinators, it is important that no blooming weeds are in the field during application.

Ground applications have proven superior to aerial applications of insecticides because of the increased volume of water used.

Chemicals are chosen based on efficacy, length of control, label specifications, and grower experience. For example, lambda-cyhalothrin (Warrior) and bifenthrin (Capture) may be held back from first application(s) in case something needs to be used when bees are present, because these two chemicals are less toxic to bees at lower rates. Dimethoate (Dimethoate) and methidathion (Supracide) is a commonly used tank mix. An advantage of dimethoate is that bees can be placed in the field sooner following application. Dimethoate use is less common in California; methamidaphos (Monitor) and methidathion (Supracide) are more commonly used.

Many of the insecticides listed for lygus bug control are scheduled to be reviewed by EPA under the Food Quality Protection Act (FQPA). Listed below are the insecticides registered for lygus bug control.

Aldicarb (Temik), a carbamate, is labeled for use only in California. It is fairly selective and could be part of a "preventative" program, which could include mites, aphids, and lygus. If large lygus populations migrate into the field, the grower may use an over-the-top treatment. If applied prior to placement of the pollinators, aldicarb (Temik) may eliminate the pre-bee insecticide application and reduce the number of miticide applications. It has a different delivery mechanism than other insecticides currently in use, requiring ingestion rather than contact to kill.

Bifenthrin (Capture) has been one of the most effective materials available for lygus control in seed alfalfa since its 24c registration in California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. It is a pyrethroid and, as such, is a non-selective insecticide/miticide. As with most pyrethroids, its use may cause flare-ups of mites. Unfortunately, in recent years, the length of the effective control period has declined due to the onset of resistance documented by bioassays conducted in commercial fields. The registration for seed alfalfa was modified in 1996 to limit the number of applications to once per season. Capture is relatively safe to honeybees, but when combined with Comite (propargite), will eliminate leafcutting bee populations for 8-10 days. Capture has lost some of its effectiveness in the Columbia Basin. Lambda-cyhalothrin (Warrior) has replaced it is many instances. Bifenthrin (Capture) is also used to control alfalfa weevil and aphids.

Chlorpyrifos (Lorsban) has moderate selectivity and moderate residual activity. It is somewhat more effective than methomyl (Lannate) for lygus control, but can have a negative impact on pollinators. Because this material provides good armyworm control, it should be used late in the season for that purpose. It is only registered for lygus control in California, Oregon, and Washington.

Dimethoate (Dimethoate) is used as a pre-bloom treatment for lygus bug control or as a post-bloom clean-up spray.

Endosulfan (Endosulfan, Thiodan) is an older material that in the past was used primarily to control aphids in alfalfa seed fields. It is now used in combination with bifenthrin (Capture) to control lygus bugs. It is relatively nontoxic to some beneficial insects. Endosulfan (Thiodan) is used in California and has a 24c registration in Idaho, Oregon, and Washington. Endosulfan is also used to control spotted alfalfa aphids.

Formetanate hydrochloride (Carzol) is a carbamate. It knocks down adult populations, but has little residual activity. It is toxic to predatory mites. It is expensive compared to other available materials. Carzol is used primarily in California.

Lambda-cyhalothrin (Warrior) was recently registered for use on seed alfalfa. It is a third-generation synthetic pyrethroid. It controls lygus in addition to weevils, worms, aphids, and seed chalcid. It is highly toxic to bees exposed to direct treatment or residues in the field. Warrior is also used for spider mite suppression and for grasshopper control.

Malathion (Malathion) is an organophosphate that controls lygus, aphids, alfalfa weevil, and caterpillars. It is broad spectrum, toxic to bees, and, like methyl parathion, must be applied one to seven days prior to releasing bees into fields depending on formulation and rate. Malathion is not registered for lygus control in Idaho, Oregon, or Washington.

Methamidophos (Monitor) has a 24c registration for use on alfalfa seed in California; there are no registrations in other states. It is the most frequently used material for controlling insect pests (primarily lygus) prior to the placement of pollinators in the field. Monitor is an organophosphate with moderate selectivity. It is toxic to bees, so applications cannot be made when pollinators are in the field.

Methidathion (Supracide) registration was lost several years ago, but it has a 24c registration in California, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming. This organophosphate is moderately selective with a short period of residual activity. It is used prior to placing bees in the field for pollination and is thought to be safer to bees (queen and brood) than methamidophos (Monitor). Supracide is also used for alfalfa weevil and aphid control.

Methomyl (Lannate) is a carbamate with low selectivity and short residual activity. It must be used at high rates to control lygus, but at high rates it negatively impacts pollinators. It is used primarily to control aphids and armyworms, and it is reserved until late in the season for that purpose.

Methyl parathion (Penncap-M, Methyl Parathion) is a broad-spectrum organophosphate that controls lygus, aphids, alfalfa weevil, and caterpillars. It is toxic to bees and depending on the formulation and rate must be applied one to seven days prior to releasing bees into fields.

Naled (Dibrom) may work well in combination with aldicarb (Temik) (California only) and with some aphicides like pymetrozine (Fulfill). It is a relatively inexpensive, non-selective organophosphate that has a 24c registration in Idaho, Oregon, Nevada, and Washington. It can be applied as a quick knockdown material with little residual activity to control lygus populations that migrate into the field. It kills both adults and nymphs on contact. The pollinators must be moved out of the field prior to application, but can return to the field more quickly than if alternate materials with longer residual activity were used. Naled (Dibrom) is not recommended during early season, because night applications can kill either leafcutting or alkali bees the following day. Naled (Dibrom) also kills the beneficial big-eyed bugs and damsel bugs.

Oxydemeton methyl (MSR) is an older organophosphate that had fallen into disuse for a period due to the perception of high levels of lygus resistance. As a result of bioassays that indicated it was effective against lygus populations, this material is once again being used in seed fields. It only controls lygus in the early instar stages of development, and has moderate selectivity and a short residual period. It is somewhat more expensive than other options. MSR is also used for aphid control.

Permethrin (Ambush, Pounce) is a synthetic pyrethroid. It is only used once per season in rotation with other materials to delay resistance development. As with other pyrethroids, it may cause an increase in mite populations. Permethrin is not used in Washington due to bee toxicity. Permethrin is also used for aphids, alfalfa weevils, cutworms, and armyworms.

Zeta-cypermethrin (Mustang) is used as a pre-bloom treatment for lygus control and is registered for various other insects.

Appendix B shows examples of lygus control regimens.

Aphids *(Therioaphis Acyrthosiphon, Macrosiphum,* and *Aphis* spp.)
After lygus bugs, aphids are the most economically damaging insect pests to alfalfa seed production in the intermountain west, except in Montana, where aphids are the most important insect pests. In red clover seed, pea aphids are usually the most important insect pest. In California, aphids are not problematic because all of the non-dormant varieties grown for seed are resistant. The spotted alfalfa aphid typically causes the most damage in most areas of the West. These aphids overwinter as adult females inside the alfalfa crown where they lay egg that survive until spring. Aphids hatch from the eggs in June and reach peak populations by late July. As many as 20 generations can occur each year. See previous crop-stage section for general discussion of aphids impacting alfalfa seed production.

Damage: Large aphid populations may stunt plants, cause foliage to wilt and/or yellow; fields with heavy aphid infestation appear dried. Aphid infestation during this crop stage may prevent or delay flowering, which can compromise seed maturation and bee reproduction. During the vegetative growth stage of the crop, spotted aphids are generally found on the undersides of leaves on the lower portions of the plant, where they feed on mature leaves. Pea aphids concentrate at the newer growing tips in the top portion of the plant. Nymphs and adults of both aphids feed by piercing leaf tissue and sucking on the plant juices. Spotted and cowpea aphids, in particular, secrete large quantities of honeydew from their hindguts, which encourages the growth of black sooty mold on alfalfa foliage. (Blue alfalfa aphids are also copious honeydew producers, but their excretions do not seem to correlate as directly with sooty mold formation.)

Cultural Control: Maintenance of a healthy, vigorous, mature stand is an effective strategy for minimizing aphid damage.

Biological Control: Parasitic wasps, syrphid flies, damsel bugs, minute pirate bugs, lacewings, and ladybird beetle adults and larvae are the most important natural enemies of aphids; conservation of their populations should be considered in deciding whether to use chemical control. See aphid biological control discussion in Pre-Plant/Establishment crop-stage section.

Chemical Control: Refer to Table 3 for specific insecticide information. The pest complex, climate, and resistance issues vary among the regions. Pirimicarb (Pirimor) is being used for in-season aphids. This chemical is very specific to pea and blue aphids and has no efficacy on spotted aphids. It is not registered in California. In the Yellowstone Valley, as well as in irrigated clover seed production, oxydemeton-methyl (MSR) in combination with bifenthrin (Capture) offers better residual control of aphids. Resistance to bifentrhin (Capture) is being noted in many areas of Montana. Spotted alfalfa aphids are difficult to control. Lambda-cyhalothrin (Warrior), bifenthrin (Capture), thiodan (Endosulfan, Phaser) and carbofuran (Furadan) are common control measures. Pea aphids are controlled with chlorpyrifos (Lorsban) in rainfed red clover seed prior to bloom. Organophosphates are used as an in-season tool to clean fields in some growing regions. Generally speaking, newly planted fields are treated more aggressively and spotted alfalfa aphids are treated aggressively, as they are difficult to control and their populations can increase very rapidly.

Alfalfa Weevils *(Hypera postica)* and **Egyptian Alfalfa Weevils** *(H. brunneipennis)*
Alfalfa weevil is the most destructive insect of forage alfalfa in the intermountain western region of the United States and also infests alfalfa grown for seed. Adults overwinter in alfalfa crowns, plant debris, and adjoining areas. They emerge in March and begin feeding and mating. Females chew holes in alfalfa stems, laying 5 to 20 eggs in each hole. While the alfalfa weevil can be a problem throughout the growing season, it is typically most injurious in the early spring during the first harvest cycle. Both the larval and adult stages cause damage. Adult alfalfa weevils are pests only on alfalfa, but can pass through all developmental stages on clover. Alfalfa weevil is not a problem in California alfalfa seed production. Management of alfalfa weevil for seed producers is

different than for forage producers because seed producers are constrained by the need to protect pollinators. Pre-bloom sprays on alfalfa grown for seed typically target alfalfa weevil, lygus bug, and pea aphids.

Egyptian alfalfa weevil is a pest in alfalfa fields in California; it is not found in the Pacific Northwestern or Intermountain states. It is not a problem in new plantings. In established stands, depending on the timing of the infestation, populations are controlled either through clipping or a chemical application.

<u>Damage</u>: Larvae hatch and migrate to the plant terminals in spring, where they feed on the growing stem and expanding leaves. Older larvae feed mostly on open leaflets, but also on terminals buds. Larvae complete development in 3 to 4 weeks. Damaging larval infestations slow plant growth, skeletonize leaves, destroy buds, and delay flower formation, therefore seed set. High larval densities result in dried foliage and a grayish or frosted appearance, or complete defoliation. Weevils are most damaging in areas with short growing seasons where the crop is not clipped prior to starting a seed crop.

<u>Cultural Control</u>: Clip-back/set-back helps to control alfalfa weevils. Field burning is used for control in the Walla Walla Valley. Depending upon timing of the infestation, Egyptian alfalfa weevil may be controlled by clipping.

<u>Biological Control</u>: Wasps have been released for biological control of alfalfa weevil; refer to the Pre-Plant/Establishment crop-stage section for more information

<u>Chemical Control</u>: When second- to third-instar larvae numbers reach threshold levels, insecticides may be applied. Experience with this insect has shown that treatment should be applied when necessary, but not prophylactically. For Egyptian alfalfa weevil in California, chlorpyrifos (Lorsban) is the most commonly used control. Lambda-cyhalothrin (Warrior) is even more efficacious, but is typically reserved for lygus bug control, as resistance develops with overuse of this pyrethroid. Phosmet (Imidan) is another option, but is not very effective.

Alfalfa Seed Chalcid *(Bruchophagus roddi)*
Life cycle and damage of this pest are discussed in the Pre-Plant/Establishment section. Since chemical control is not an option, cultural control methods are employed vigilantly throughout the season. During the vegetative growth stage of the seed crop, growers keep volunteer alfalfa and alternate hosts outside of field areas mowed to remove chalcid habitat. Properly timed and uniformly scheduled within an area, clip-back/set-back (described in detail in the introduction to this Vegetative Growth section) is also used as a cultural method for controlling the alfalfa seed chalcid. If all fields are near the same stage of maturity due to a uniform clip-back/set-back schedule, seed is not at a susceptible stage of development when peak emergence of chalcid occurs.

Blister Beetles *(Epicauta* spp.)
Blister beetles are most commonly found in Montana and do not infest alfalfa seed crops in the Treasure Valley of Idaho and Oregon or California. Most species of blister beetle

have one generation per year. Adults emerge from the soil throughout the growing season, but periods of peak activity vary with the species. While the adult can cause direct damage to alfalfa, the larvae become parasites of grasshoppers (thereby having a beneficial effect where grasshoppers are problematic) and ground-nesting bees' eggs (thereby impacting the pollinator complex).

Damage: The adult feeds on the upper leaves and flowers of the plants, leaving ragged leaves and stunted plants, generally in small areas of a field. These insects generally leave the field before detection or chemical application.

Cutworms *(Peridroma, Euxoa, Agrotis, Feltia, Amathes,* and *Scotogramma* spp.)
In established stands, cutworm problems typically occur early in the spring, during the first harvest cycle. Cutworm damage can first be detected by the presence of clipped stems early in the spring and lack of green-up. Outbreaks are sporadic, often isolated by many years in which there is little damage. Biology of individual cutworms species varies, with overwintering occurring in egg through larval stages. More details are provided in the Pre-Plant/Establishment section.

Damage: Climbing cutworm species will feed on leaves and above-ground plant parts, while ground-dwelling cutworm species clip stems. Feeding may begin in the fall in more southerly locations, but further north larval damage begins in early spring on new alfalfa growth. Feeding continues throughout the spring, depending on the activity of each species, until pupation in early summer. Established stands are not likely to be killed, but seed yields can be reduced.

Cultural Control: The most effective cultural controls are generally applied in the previous crop-stage section, Pre-Plant/Establishment; details on chemical control options for cutworms can be found in Table 3 and in the previous crop-stage.

Biological Control: No intentionally applied biological control agents are known to affect this pest. Predators, parasites, and diseases usually keep cutworms populations in check, but when these natural regulators fail, populations can increase dramatically and cause damage to localized alfalfa seed fields. See discussion of fungal pathogens promoted by wet weather under Biological Control/Cutworms in the Pre-Plant/Establishment section.

Chemical Control: Refer to Table 3 for specific insecticide information and to the Pre-Plant/Establishment section for a discussion of chemical controls. Control measures taken for lygus and aphids will generally control cutworms, blister beetles, and armyworms.

Slugs (various species)
These land mollusks feed on rainfed red and crimson clover, damaging roots, crowns, leaves and fruit.

Chemical Control:
Metaldahyde baits (several brands) are used throughout the establishment and vegetative growth stages.

Critical Needs for Management of Insects in Western U.S. Alfalfa and Clover Seed During Vegetative Growth

Research

- Develop selective systemic compounds for red clover and alfalfa seed that do not adversely affect pollinators.
- Develop more growing degree-day (GDD) modeling for additional insect pests and beneficial insects.
- Develop puncture wound method for early detection of weevils.
- Research biological controls for lygus, which would include fungal pathogens and parasites.
- Review economic thresholds for insect pests. Current thresholds are not dynamic enough to reflect prices and other concerns.
- Develop insecticides with alternative modes of action for lygus control.
- Determine effect of new compounds on natural enemies and pollinators.
- Improve diagnostics of lygus damage at bud stage and seed stage.
- Improve insecticide resistance management programs for key pests.
- Develop insect management plans that mitigate negative effects on general predators and biological control agents.
- Improve economic threshold development and evaluation.
- Improve pest and beneficial monitoring techniques.
- Examine biopesticides for pest management.
- Examine and understand the interaction of chemical, biological and cultural pest control techniques.
- Research block planting of crops on a regional basis.

Regulatory

- Preserve a wide range of insecticide chemistries and mode-of-action choices for resistance management and pollinator protection.
- Preserve dimethoate registration.
- Provide clarity on pesticide application issue around salmon-bearing streams. EPA needs information to support approved regulatory labels.
- Streamline label requirements for field posting after spraying. Current requirements vary by chemical (e.g., posting times vary, posting required on all 4 corners of the field and every entry point). It is very labor intensive with the number of small fields.

Education

- Educate growers about degree-day modeling and threshold-based pest control recommendations.
- Continue education of regulators (in a field setting) about the unique pest management needs due to pollinator preservation.

POLLINATION AND SEED SET

The leafcutting bee*, Megachile rotundata*, is the primary pollinator in alfalfa seed production in the northwestern states. This bee along with the alkali Bee*, Nomia melanderia,* is responsible for increasing yields to 300 pounds per acre more in the Northwest than in other alfalfa seed-producing states. The advantage of leafcutting bees is that they usually forage in the field where they nest, making on-site management easier for the grower. Alfalfa pollination with leafcutting bees must be accomplished over the 30- to 40-day lifespan of the bee. Leafcutting bees are placed in alfalfa fields from the end of May through July or as specified by the producer's management scheme. Timing is critical because climatic conditions influence pollination, seed set, and bee survival. Timely pollination is essential for seed set prior to autumn rains, which damage mature seeds ready for harvest.

The native alkali bee has become a major pollinator of the introduced alfalfa plant. This bee differs from the other pollinators in that the females prepare nests in holes in the soil. Alkali bee females trip at least 95% of the alfalfa flowers they visit as they gather pollen for the nest. Females also forage blooms in lower foliage and fly in cooler, windier weather than most other alfalfa pollinators. Females tend to forage close to the nest site (within a 1-mile radius), although they have been found up to 7 miles away.

For maximum seed production with alkali bees, peak bloom of alfalfa should coincide with peak activity of females. This can vary from area to area ranging in emergence dates of mid-May through August. Large alkali bee populations are needed for alfalfa seed production. A good natural nesting site will average approximately 1 million bees per acre. The maximum population in artificial beds is approximately 5.5 million bees per acre. Nesting sites for the alkali bee can be natural or artificial where soil and moisture conditions are prepared to simulate natural conditions.

The honeybee, *Apis mellifera*, is the pollinator of choice in the major seed production areas of California and the southwestern states. Management of this bee is different from the leafcutting bee and alkali bee in that seed producers using honeybees generally contract with honeybee producers to set colonies of the bees in their fields when pollination is required. With leafcutting bees and alkali bees, the seed producers are most often responsible for their management although some producers work with custom leafcutting pollination services.

Clover seed is mostly dependent on honeybees for pollination although, when present, native bumblebees are quite efficient. Due to their habit of staying in the fields through the night (in contrast to honeybees, which retreat to their hives), bumblebees can pollinate as much as, or even more than, the managed honeybees.

Leafcutting bees, alkali bees, and honeybees require management. They require nesting areas (e.g., holes, hives, shelters) and they need to be protected from diseases, parasites, predators, and insecticides. If the bees are killed at anytime during the pollination period due to misapplication of chemicals the seed set for the season is essentially over.

Critical Needs for Management of Pollinators at Pollination and Seed Set

Research

- Develop more selective insecticides that do not harm pollinators.
- Support Bee Health Initiative for control of diseases (e.g., chalkbrood), parasites, and other issues (e.g., pollen mass) impacting pollinator bees.
- Support research at the USDA-ARS Logan Bee Lab.
- Research alternative pollinators.
- Continue research into alkali bees as pollinators.
- Improve understanding of pollinator biology and management.
- Improve rates and timing of pollinator movement into fields.
- Understand factors that limit pollinator effectiveness.

Regulatory

- None listed

Education

- Educate non-alfalfa and clover seed growers about the importance of pollinators and the potential impacts of their activities on pollinators.
- Educate the general public on the importance of pollinator bees.

Weeds

Noxious weeds may be hand-pulled during pollination and seed set. Dodder and Canada thistle are spot sprayed during this crop stage with contact herbicides such as gramoxone (Paraquat) and glyphosate (Roundup). In California, dodder is removed by hand. Workers clip the alfalfa plants to which dodder is attached and carry all of the vegetation from the field. Alternatively, growers use propane torches to burn the infested patches. In the Treasure Valley, large patches of dodder are burned down using gramoxone (Paraquat), then burned once they are dry.

Critical Needs for Management of Weeds in Western U.S. Alfalfa and Clover Seed at Pollination and Seed Set

Research

- Research more dodder management techniques.
- Research more Canada thistle management techniques.

Regulatory

- Permit spot burning for dodder management in California.

Education

- None listed.

Diseases

Verticillium wilt, alfalfa mosaic virus, and bacterial wilt may be present at this stage in areas other than California. Most recently released varieties have sufficient genetic resistance to Verticillium wilt and bacterial wilt to prevent incidence of these diseases.

Critical Needs for Management of Diseases in Western U.S. Alfalfa and Clover Seed at Pollination and Seed Set

Research

- Develop new control measures for seedborne diseases (Verticillium wilt, alfalfa mosaic virus, and Bacterial wilt).

Regulatory

- Facilitate phytosanitary certification of seed and testing for seed exports leaving the U.S.
- Improve and expedite phytosanitary certification for international seed shipments.

Education

- Provide extension publications on management of alfalfa diseases in seed production.

Insects

Refer to Table 3 for specific insecticide information and to previous crop-stage sections for more detailed descriptions of specific insect pests and their life cycles.

Lygus Bugs *(Lygus* spp.)
Older lygus nymphs and adults feed on the juices of immature seeds, resulting in dark brown shriveled seeds that will not germinate.

<u>Cultural Control</u>: Suppression of weed hosts in and around alfalfa seed fields is important. Known alternative host plants include mustards, common lambsquarters, kochia, Russian knapweed, and Russian thistle. Harvest of nearby forage alfalfa fields can cause mobile adults to relocate, infesting nearby seed fields or causing increases in adult populations. However, harvesting of nearby fields before adults are present results in high mortality of immatures.

<u>Biological Control</u>: Damsel bugs (nabids) and big-eyed bugs are important lygus predators. Lygus parasitoids are also present in the region, however their impact on populations is not known. Monitoring is frequent.

<u>Chemical Control</u>: A second insecticide application is made during bloom, usually when lygus bugs (adults plus nymphs) reach established thresholds (which vary by location and by growth stage of the plant), and before nymphs reach fourth instar stage (half grown).

Lygus bugs were discussed in detail in the Vegetative Growth section. All insecticide applications at this time are made in the evenings when the bees are nesting. All chemicals used during this stage are softer on bees and tend to be flash killers/fast acting with short residual activity.

- Lambda-cyhalothrin (Warrior) is used at a lower rate when leafcutting bees are being used for pollination.
- Oxymedeton-methyl (MSR) may be used; it is more effective on small instars than on larger bugs and it works better early season when foliage is still green.
- Bifenthrin (Capture) is used at a 2/3 rate when leafcutting bees are used as pollinators. Among materials available, bifenthrin (Capture) is least destructive of predators, although resistance development is always a consideration.
- Naled (Dibrom) is used at very low rates in combination with lambda-cyhalothrin (Warrior). It is harsher on beneficials (big-eyed bug and damsel bugs).
- California utilizes additional chemicals and different strategies because growers there use honeybees. See lygus information in the previous section, Vegetative Growth.

Aphids *(Therioaphis Acyrthosiphon, Macrosiphum,* and *Aphis* spp.)
Spotted aphids, in particular, excrete large quantities of honeydew during this timeframe, which encourages growth of sooty mold.

<u>Chemical Control</u>:

- Pirimicarb (Pirimor) works very well. It is softer on bees and natural enemies than many other options. It does not control spotted aphid.
- Oxymedeton-methyl (MSR) works very well. It is softer on bees and natural enemies than many other options. It does not control spotted aphid.
- Pymetrozine (Fulfill) works like pirimicarb (Pirimor). It is a specific aphicide and its efficacy is variable. It does not control spotted aphid.
- Endosulfan (Thiodan, Phaser) is harder on natural enemies and pollinators, but it controls spotted aphid.
- Bifenthrin (Capture) and lambda cyhalothrin (Warrior) control spotted aphids. Low rates are used when leafcutting bees are present.

Armyworm (*Spodoptera praefica* and *Mamestra configurata*)
Armyworms are infrequent pests in alfalfa seed production fields. They generally feed at night and rest under plant debris or shaded areas of the soil surface during the day. Because these typically do not overwinter in the region, their occasional outbreak is related to the migration of egg-laying adults into the region. In California, growers have problems with armyworms most years.

<u>Damage</u>: Armyworms usually have two generations per season; the first generation is generally detected in July. Moths lay their eggs on plants such as lambsquarters and the developing larvae move into alfalfa as they get older. Outbreaks of armyworms usually occur in weedy spots. Only California has economic damage caused by armyworm.

Spider Mites *(Tetranychus* spp.)
Individual two-spotted spider mites *(Tetranychus urticae* Koch) are difficult to find with the naked eye, but established colonies can be recognized by patches of yellow, brown, green, or occasionally orange coloration. California also has strawberry and pacific spider mites (*T. turkestani* and *T. pacificus*).

Damage: Mites overwinter as adults in debris or other protected locations. Mite colonies spin fine sheets of webbing that can enclose flower stalks, seriously inhibiting pollination. Mites feed by puncturing the undersides of leaves. Affected foliage takes on a white, stippled appearance on the upper leaf surfaces. Heavy infestations kill plants.

Cultural Control: Mite infestations are mainly an issue in plants that have been stressed by drought in July. Adequate irrigation during early drought reduces mite infestations.

Biological Control: Predacious mites such as *Phytoseiulus persimilis* can be used to control two-spotted spider mite. When using predators to help control spider mites, it is extremely important to release the predators as soon as spider mites are observed on the plants. Predatory mites do not work in California and are not released in the Treasure Valley. *Galendromus occidentalis* and *Neosieulis fallacies* are naturally occurring predatory mites that provide some control of spider mites. The impact of predators on spider mite numbers in other seed production areas is largely unknown. Propargite (Comite) and hexythiazox (Onager) are reasonably selective miticides and would tend to preserve populations of these mite predators. Abamectin (Agrimek) is equally toxic to beneficial and pestiferous mites. Other predators such as minute pirate bugs and small lady beetles in the genus *Stethorus* also feed on spider mites, but their importance in alfalfa seed production has not been established.

Chemical Control: Before deciding to treat for spider mites, growers consider the effects of the application. Most insecticides have a detrimental effect on spider mite natural enemies. Few insecticides/miticides are toxic to two-spotted spider mites. Treatment for spider mites may be justified when 25% of the leaves show damage in early summer, and 50% in mid summer. Refer to Table 3 for specific insecticide information.

- Propargite (Comite) tank mixed with sulfur is the only miticide that has not shown potential for resistance. It is not used with bifenthrin (Capture) when leafcutting bees are present.
- Abamectin (Agrimek) is excellent but resistance is a concern. Abamectin is not used in clover seed.
- Hexythiazox (Onager) is a problem because resistance develops easily.

Grasshoppers (*Melanoplus* spp.)
Grasshoppers are one of a number of forb-feeding species that can severely damage seed alfalfa fields. There are generally five nymphal stages. Adults of most species are winged and are strong fliers. Most species in alfalfa overwinter in the egg stage of development and hatch in early spring.

Damage: Grasshoppers are voracious eaters. When populations are high they can cause severe defoliation. If densities are unusually high, they will eat the entire alfalfa plant, including the crown, stems, buds, flowers, and unripe seedpods. Damage this extensive is not common. Older nymphal stages will often clip flowering or seed-bearing stalks off at the base to feed on soft stem tissue.

Cultural Control: The grasshopper species that damage seed alfalfa fields are almost all forb feeders, not grass feeders. Alfalfa and clover seed growers reduce the attractiveness of seed field margins by encouraging a dense grassy cover that contains few broadleaf plants. This significantly reduces the numbers of pest grasshoppers migrating into the alfalfa crop from the field edge. Dense stands of sweet clover on edges of seed fields are avoided. Alfalfa fields can become infested with grasshoppers hatched within the field or migrating from border areas and open range or BLM land. Individual growers can usually protect a field from small infestations, but a large outbreak requires a regional program.

Biological Control: A disease-causing microbial organism, *Nosema locustae*, has been used successfully to reduce grasshopper densities. *N. locustae* is introduced into the crop incorporated into wheat bran at the rate of 1×10^9 spores per acre. Bait products are most attractive to younger, immature grasshoppers so this product should be applied early when grasshoppers are younger. When grasshoppers eat the bait, they ingest the spores. The spores subsequently germinate internally, killing or weakening the grasshopper. Typically, *N. locustae* takes longer to kill grasshoppers than insecticides do, but it can provide an effective way to keep grasshopper numbers under control. There are several important natural enemies that help control grasshopper populations. These include blister beetles, ground beetles, and several parasitic flies. Many species of birds and mammals also feed on grasshoppers.

Chemical Control: Grasshopper numbers are assayed routinely as soon as hatch occurs in early spring. They are easiest to control in the nymph stage, before they become adults and their wings appear. If a range of rates is recommended for a chemical, the higher rate will be used late in the summer when the adult stage is most common, as adults are more difficult to control.

Insecticides may be applied as spray or incorporated into baits. Bait formulations tend to be more effective on immature stages and are not typically used on adults. Border treatments of insecticide in 150-foot swaths around the periphery of the alfalfa field are often sufficient to prevent re-entry of grasshoppers. In years with high grasshopper populations, control may be difficult; multiple border treatments may be required. A border spray should be effective for at least 7 to 14 days. The residual activity of the treatments will vary with the chemical and the environmental conditions. It is important to monitor the borders and the crop margins after treatment to make sure grasshoppers do not re-enter the field. Refer to Table 3 for specific insecticide information.

Alfalfa Seed Chalcid *(Bruchophagus roddi)*
Alfalfa seed chalcid overwinters in the larval stage inside the alfalfa seed, emerging late in the following spring. Adults emerging in May and June lay eggs in seed pods that

hatch and infest developing seed. Chalcids select developing alfalfa seed pods wherever available, with the most common seed source being plants growing outside of fields. Several generations of the chalcid are completed each year, with the levels of infestation in seed becoming progressively higher as chalcid populations increase in mid- and late summer. Research has shown that up to 80% of seed harvested in September may be infested, absent chemical controls.

Damage: Young seeds infested with chalcid larvae are plump and develop a premature light brown color, in contrast to healthy, uninfested seeds, which are green at this stage of development. Infested seeds will not develop. Seed loss can be as high as 15%.

Cultural Control: Cultural practices to deter alfalfa seed chalcid begin early in the season and are discussed in the Pre-Plant/Establishment and Vegetative Growth crop-stage sections. Throughout the growing season, clipping volunteer alfalfa and other alternative hosts outside the field helps reduce levels of infestation in the seed crop.

Clover Seed Weevil (*Tychius picirostris*)
The clover seed weevil is an infrequent pest of red clover. It is a small, gray weevil, approximately 1/10 of an inch long. The larvae feed on seeds.

Chemical Control:
No chemical controls are specifically aimed at clover seed weevil, but insecticides used to control pea aphids have activity on clover seed weevils as well.

Critical Needs for Management of Insects in Western U.S. Alfalfa and Clover Seed at Pollination and Seed Set

Research

- Research and improve biological control for lygus bug, including fungal pathogens, parasites, and beneficials.
- Improve economic threshold determination and monitoring techniques for pest and beneficial insect populations.
- Develop selective systemic insecticides for red clover and for alfalfa seed that do not hurt pollinators.
- Develop GDD modeling for more insect pests and beneficials.
- Research alternative modes of action for lygus bug control.
- Determine effects of new compounds on natural enemies and pollinators.
- Develop better diagnostic tools for lygus damage at bud and seed stage.

Regulatory

- Provide better access to grasshopper bait (e.g., Internet purchase).
- Provide control of grasshoppers on public land, as they migrate to croplands.

Education

- None listed.

SEED MATURATION (POST-BLOOM)

Pollinated seed embryos take approximately 30 days to mature into harvestable seed. During this time, developing seeds are subject to damage from environmental stresses, insects, and diseases.

Weeds

Same as previous crop stage.

Diseases

Sometimes if the crop environment is kept too wet or with heavy or frequent sprinkler irrigations, fungal and bacterial pathogens are encouraged. On the other hand, deficit irrigation may reduce seed yield potential.

Summer black stem, caused by *Cercospera medicaginis* may infect stems and maturing racemes causing seed to rot in the pod. This can be caused by high humidity and too frequent overhead irrigation.

Insects

Alfalfa seed chalcid continues to be an important insect to manage through seed set, harvest, and post-harvest stages.

Post-pollination control of **lygus bugs** is important to protect the developing seed, because the seeds are very susceptible to damage at this stage. Damage results from the piercing-sucking action of the bugs as they feed. Affected seeds appear shrunken and brown in color; feeding sites can be observed under magnification. Different species of adult lygus bugs are present at this stage in some western growing regions, some of which are particularly difficult to control due to insecticide resistance. Softer insecticides are not as effective on late-season lygus, therefore growers often use lower economic thresholds and harsher chemicals. There is less concern about protecting pollinators (leafcutting or alkali bees) at this stage, because they are completing their life cycle. Honeybees are not removed from the field until 30 days prior to harvest, but California is the only alfalfa seed region covered in this document that uses honeybees, and the late-season lygus species shift does not seem to occur in California alfalfa seed fields. The following is a list of chemicals commonly used to control lygus bugs at this stage:

- Methyl parathion
- Dimethoate in combination with a pyrethroid
- Carbofuran (Furadan)
- Methomyl (Lannate)
- Methamidophos (Monitor) (used in California only)

Critical Needs for Management of Insects in Western U.S. Alfalfa and Clover Seed at Seed Maturation

Research

- Improve diagnostics for lygus bug damage to seed.
- Research emerging pests that limit seed production.

- Establish and/or validate thresholds for late season pests, such as lygus, spider mites, and alfalfa seed chalcid.
- Examine selective pesticides and application timing to manage pests, preserve natural enemies, and reduce input costs.

Regulatory
- None listed.

Education
- None listed.

HARVEST

The crop is prepared for harvest by managing the soil moisture to favor seed dry-down, encourage leaf senescence, and allow any weeds present, especially dodder and nightshades, to dry. As a general rule, when 80% of the seedpods can be threshed by hand to reveal mature, hard, tan-colored seeds, the crop is ready for harvest. The crop can be dried by the use of chemical desiccants, swathing, or a combination of the two. In western Oregon, clover seed is harvested by swathing; no dessicants are used.

Chemical desiccation of the alfalfa seed crop has been practiced in the Walla Walla Valley and in parts of California, Treasure Valley, Utah, Wyoming, and Nevada. In dryer regions, during dryer years, and/or when economically indicated, growers may simply swath and allow the seed crop to dry naturally; this has been the case in recent years in most alfalfa grown for seed. Natural drying does not preclude the need for chemical desiccants prior to harvest as an alternative to windrowing. Desiccants usually provide more uniform drying, faster drying after rain, and less seed shatter. Swathing the crop presents the risk of wind damage to windrows, risk of seed shatter, and increased cost. Desiccants used include:

- Diquat and gramoxone (Reglone + Rely) tank mix. This has been used in California in the past, but has been lost because California growers do not have the non-food status designation on their crop.
- Endothal (Des-i-cate) works too slowly.
- Gramoxone (Paraquat) does not work as well as a tank mix.
- Diquat (Reglone) requires two applications if growth is heavy, therefore it is slow and costly.
-

Prior to harvest and desiccation, beekeepers remove all honeybees from the field. Alkali bees normally will have stopped flying before desiccation so removal is not a consideration. Typically leafcutting bees are through flying before desiccation but the bee nests and shelters are left in the field until after harvest because they are more accessible at that time.

Nematodes

Alfalfa Stem Nematode *(Ditylenchus dipsaci)*
Infection of flower buds by alfalfa stem nematode is a common problem observed in alfalfa fields. Up to 17,000 nematodes have been recovered from one pound of uncleaned seed. Alfalfa seed must be certified nematode free.

Weeds

Weeds not thoroughly dried in the alfalfa windrows or by desiccants obstruct and slow harvest operations. Dodder (*Cuscuta spp.*), in particular, can hinder the harvest process. Dodder-infested spots are avoided during harvest, then burned after harvest. Numerous types of weed seeds are subject to harvest along with the crop, the presence of which contaminates the harvested seed (see also Post-Harvest crop-stage section).

Diseases

Anthracnose (*Colletotrichum trifolii*)
Fall is a peak occurrence time for this disease pest, which is described in greater detail in the Pre-Plant/Establishment crop-stage section.

Cultural Controls:
Producers avoid spreading spores from plant debris on harvest equipment to uninfected fields.

Insects

Aphids *(Therioaphis Acyrthosiphon, Macrosiphum,* and *Aphis* spp.)
As mentioned in previous sections, aphids secrete honeydew onto alfalfa and clover plants. Besides encouraging growth of sooty mold, honeydew in large quantities hinders harvest. Cowpea, spotted, and blue alfalfa aphid secrete the greatest quantities of honeydew.

Alfalfa Seed Chalcid *(Bruchophagus roddi*
Harvesting early removes the host crop from the field before the highest chalcid infestations that occur during late August and September.

Critical Needs for Pest Management of Western U.S. Alfalfa and Clover Seed at Harvest

Research
- None listed.

Regulatory
- Reinstate tank mix desiccant for California.

Education
- Educate growers about the problems with exporting straw as a mulch.

POST-HARVEST

After seed harvest, the remaining straw must be reduced or removed from the field. Some growers utilize the straw chopper attachment on the combine to shred and distribute the straw on the ground; others burn the residue. Burning is not necessary for residue management in western Oregon. After the straw is managed, at least one irrigation cycle occurs to germinate weed seeds and any alfalfa seeds that have shattered to the ground during harvesting operations. The field is then lightly cultivated with a disc or skew treader to incorporate straw and chaff into the soil and destroy germinating weeds and volunteer alfalfa. In-season cultivation is not practiced in western Oregon.

Leafcutting bee nests remaining in the field are brought in after harvest. Larvae are stripped from the nests and placed in cold storage where they overwinter until they are needed for the upcoming pollination season.

Alfalfa seed, along with weed seed and chaff, is delivered from the field in metal seed boxes and stored for cleaning. The cleaning process, designed to remove weed seeds and chaff, begins shortly after harvest and continues through mid-February or early March. Each field is assigned a lot number and lots are kept separate as they go through the cleaning process. Each lot is checked for purity and germ after cleaning and must meet company standards for those characteristics. Once seed is cleaned it is stored in metal boxes until the customer requests shipment. Some weeds' seeds are particularly difficult to remove from alfalfa seed once it has been harvested because of their similarity in weight and size to the seed itself. Various types of seed cleaning equipment and other techniques are used to remove weed seed from alfalfa seed, but each time the alfalfa seed is processed a certain percentage of the alfalfa seed is lost along with the weed seed. Hairy nightshade *(Solanum nigrum)* can be especially problematic after harvest because the berries it produces become mixed with the alfalfa seed, increasing the moisture content of the pre-conditioned, stored seed and possibly causing seed to heat, mold, and stain.

Packaging into 50-pound bags occurs when the customer requests shipments. Customers request treated or non-treated product depending on their needs. If the seed is to be treated with fungicide and/or pre-inoculant, treatment is applied in a self-contained application system as part of the packaging process. Metalaxyl (Allegience, Apron) and metalaxyl-M (Ridomil Gold) are standard seed-treatment fungicides. Standard pre-inoculants, which coat the seed with nitrogen-fixing bacteria, are Nitragin Gold and Dormal.

Weeds

Canada thistle, quackgrass, and field bindweed may be spot sprayed during this crop stage. This control is most effective following a moderate frost.

Insects

Standard residue management tactics as described above (i.e., burning, cultivation, irrigation) are critical tools in the year-round program to control alfalfa seed chalcid. These activities not only manage weed seeds, but also destroy alfalfa seed infested with chalcid. Seed not destroyed via burning is encouraged to rot by the post-residue-management irrigation. Sometimes irrigation is put off until the spring, but that is not recommended, because this timing is less effective in controlling chalcid and can also lead to vertebrate pest infestations.

Vertebrate Pests

Gophers are a problem, especially in alfalfa fields under center pivot irrigation. Baits and traps are used, including zinc phosphide, gopher bombs, and underground strychnine baits.

Critical Needs for Pest Management of Western U.S. Alfalfa and Clover Seed at Post-Harvest

Research

- Research improvements in fall storage of pollinator bees, including control of pollinator parasites in storage.

Regulatory

- Change Washington State law so that gophers can be trapped.
- Preserve burning as a better management practice for straw removal in fall or spring.

Education

- None listed.

DORMANCY

Dormant-season herbicides are applied in the late fall (November–December) or, more typically, in the late winter/early spring (February–March).

Weeds

The following chemicals are available and used to some degree as dormant-season herbicides. Many of these products have 18- to 36-month plant-back restrictions, so choice of chemical depends on length of time alfalfa and clover seed will remain in production. Dormancy herbicides are not used in irrigated red clover.

- Diuron (Karmex) users cannot replant to any crop within two years after application.
- Hexazinone (Velpar, used only in California) also works on perennials including Canada thistle, quackgrass.
- MCPA amine (MCPA, used only for red clover in western Oregon) is effective on broadleaves such as Canada thistle, dandelion, annual sowthistle, and prickly lettuce. It has poor activity on vetch and groundsel, but is the only herbicide with activity on those weeds.
- Metribuzin (Sencor) has a plant-back restriction of 4 months for potatoes, 4 to 8 months for barley and wheat (depending on variety), and 18 months for sugarbeets and onions.
- Norflurazon (Zorial) has a plant-back restriction of 16 months for soybeans and asparagus; other rotational crops must be bioassayed four months after application.
- Pronamide (Kerb) has a plant-back restriction of 3 to 7 months (depending on rate of herbicide used) for sugarbeets and onions, 3 to 5 months for beans and carrots, and one year for most other crops.
- Simazine (Princep) (used only in Washington) users cannot re-plant an alfalfa seed crop without risk of crop injury.
- Terbacil (Sinbar) users cannot replant treated area to any crop within two years of application.
- Trifluralin (Treflan, used only in California) has a plant-back restriction of 1 year for crops not listed on Treflan label.

TAKE-OUT/STAND REMOVAL

A combination of herbicide and/or cultivation is employed to remove alfalfa and clover seed stands. The method selected depends largely upon the grower's choice of subsequent rotational crop. Rotation crops such as corn, wheat, or other cereal grains allow the use of broadleaf herbicides, which reduce the potential of re-establishing alfalfa from volunteers. Phenoxy herbicides in tank mixes with glyphosate (Roundup) are sometimes used to kill the stand. Plant-back restrictions are determined by the residual activity of each herbicide and its impact upon the specified crop. In western Oregon, herbicides are not used to aid in stand removal; it is strictly mechanical.

An example of a mechanical sequence for stand removal is to disc lightly, water heavily, then "crown." Crowning involves large (18- to 24-inch-wide) cultivator passes 3 to 4 inches underground, directly below the crown of the plant. This operation effectively severs the root from the crown, leaving the root to rot and be plowed under in the spring along with germinated weeds and volunteers.

When a GMO variety has been grown, additional plant-back restrictions must be considered. For example, it is prohibited to plant hay for one year because of the switch from non-food to food status.

Critical Needs for Pest Management of Western U.S. Alfalfa and Clover Seed at Take-Out/Stand Removal

Research
- None listed.

Regulatory
- None listed.

Education
- Educate growers not to use glyphosate (Roundup) when following GMO crop.

REFERENCES

Crop Profile for Alfalfa Grown for Seed in Montana. 2002. http://www.ipmcenters.org/cropprofiles/docs/mtalfalfaseed.html (website verified 12-30-04).

Idaho Alfalfa Seed Crop Profile. 2005. In press.

Baird, C. J., R. L. Stoltz, and M. M. Seyedbagheri. 1997. Clover root curculio. Entomology Fact Sheet #1. University of Idaho, Parma Research and Extension Center.

Baird, C., J. Berg, R. Bitner, G. Fisher, C. Johansen, D. A. Johnson, L. P. Kish, J. Krall, R. Lauderdale, D. F. Mayer, J. H. O'Bannon, R. Parker, R. Peaden, C. M. Rincker, W. P. Stephen, and J. Undurraga. 1991. Alfalfa seed production and pest management. WREP 12. Washington State Cooperative Extension System.

Edminster, C. W. Seed Production in the Pacific Northwest. http://www.intlseed.com/documents/info_NW_seed_production.htm (website verified 1-4-05).

Hafez, S. 1998. Alfalfa nematodes in Idaho. BUL 806. University of Idaho Cooperative Extension System, Moscow, ID.

High Plains Integrated Pest Management Guide for Colorado, Western Nebraska, Wyoming, and Montana. http://highplainsipm.org (website verified 12-30-04).

McGrath, D., et al. (eds). 2003. Pacific Northwest Insect Management Handbook. Cooperative Extension Systems of University of Idaho, Oregon State University and Washington State University, Corvalis, Oregon.

Nevada Agricultural Statistics Service. http://www.nass.usda.gov/nv/ (website verified 12-30-04).

Oregon Agricultural Information Network (OAIN), maintained by the Oregon State University Extension Service http://ludwig.arec.orst.edu/oain/SignIn.asp (website verified 02-03-05),

Oregon Clover: Welcome to the Oregon Clover Seed Industry! http://www.oregonclover.org (website verified 12-30-04).

Pscheidt, J.W. and C.M. Ocamb (eds). 2003. Pacific Northwest Plant Disease Management Handbook. Cooperative Extension Systems of University of Idaho, Oregon State University and Washington State University, Corvallis, Oregon.

Williams, R.D., A.G. Dailey (eds). 2003. Pacific Northwest Weed Management Handbook. Cooperative Extension Systems of University of Idaho, Oregon State University and Washington State University, Corvallis, Oregon.

Activity Tables for Alfalfa Seed in the Treasure Valley (Southwest Idaho and Eastern Oregon), Utah and Nevada

Cultural Activities Profile for Treasure Valley Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back[1]				-------	-------							
Irrigation[2]				-------	-------	------	-------	-------	-------	---		
Fertilization[3]			-------					-------	-------	-------	----	
Cultivation[4]			-------	-------	-------	------			-------	-------	----	
Harvest[5]								-------	-------	----		
Planting[6]		---	-------	-------				-------	-------			

Crop Monitoring Profile for Alfalfa Seed[7]

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring			----	-------	------	-------	-------	-------	-------	-------		
Weed monitoring			-------	-------	-------	-------	-------	-------	-------	-------		
Monitor soil moisture				-------	-------	-------	------	-------	-------	-------		

Pest Management Activities Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.				-------	-------	-------	-------	-------	-------	-------		
Miticide app.					---	-------	-------	----				
Herbicide app.		---	-------	-------	-------	-------	------	-------	-------	-------	----	
Hand weeding						-------	-------					
Spot treatment (hand weeding)[8]						-------	-------	-------	-------	-------		

Pollinator Management Activities Profile

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Overwinter bees[9]	-------	------	-------	-------	-------	------			-------	-------	-------	-------
Incubate bees for release[8]					-------	------	---					
Move bee shelters to field[10]					-------	------	----					
Move bees into field[11]					-------	------	----					
Move bees to overwintering sites[12]								-------	-------	-------	----	

Seasonal Pest Occurrence for Alfalfa Seed in the Treasure Valley (Southwest Idaho and Eastern Oregon), Utah and Nevada[13]

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Alfalfa aphid				--------	--------	--------	--------	--------				
Alfalfa weevil			--------	--------	--------	--------						
Armyworm/cutworms[14]		----	--------	--------	--------				--------			
Blue alfalfa aphid				-------	-------	-------	-------	-------				
Grasshoppers[14]						--------	--------	--------	--------			
Loopers[14]							--------	--------				
Lygus				-------	-------	-------	-------	-------	-------			
Pea aphid				-------	-------	-------	-------	-------				
Spider mites					-------	-------	-------	----				
Spotted alfalfa aphid				-------	-------	-------	-------	-------				

WEEDS	J	F	M	A	M	J	J	A	S	O	N	D
Annual sowthistle			----	--------	--------							
Canada thistle			----	--------	--------				----	--------		
Common lambsquarters			----	--------	--------							
Common mallow			----	--------	--------	--------	--------	--------	--------	--------		
Dodder				--------	--------	--------	--------	--------	--------			
Field bindweed			----	--------	--------				----	--------		
Kochia			----	--------	--------							
Mustards			----	--------	--------							
Nightshades			----	--------	--------							
Other grasses			----	--------	--------							
Pigweed, redroot			----	--------	--------							
Prickly lettuce			----	--------	--------							
Quackgrass			--------	--------	--------				--------	--------		
Sweet clover							--------	--------				
Yellow nutsedge			--------	--------	--------							
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers		-------	--------	--------	--------	--------	--------	--------	--------	--------	--------	-------

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[1] Set back is a cultural practice conducted using rotary mowers, swathers, roto-beaters, discs, etc. to set the crop back; i.e. delay bloom to coincide with pollinator release in June. Set-back is not done in Nevada.

[2] 85% of the acreage is furrow irrigated: siphon tubes are used to move water from irrigation ditches bordering the field into furrows that run downhill the length of the field. Workers only enter field margins for short term with proper protective equipment.

[3] For the large majority of the acreage, fertilizations operations are contracted to custom applicators.

[4] Cultivations for weed control or thinning are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 2-3 year contracts, and hence more frequent planting.

[7] Workers enter fields for a short period of time to check field conditions with respect to pest and moisture conditions. Pest scouting is conducted primarily by pesticide applicators. Proper protective equipment is used.

[8] Spot treatments to prevent sweet clover from seeding, or for small infestations of dodder, bindweed, Canada thistle.

[9] Not a field activity. Included for informational purposes only.

[10] Not a continuous activity. Shelters are moved into fields to receive pollinators and left until the end of the season.

[11] As for shelters, this is not a continuous activity. Bees are moved into shelters and left until removed in the fall.

[12] Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

[13] Indicates periods when pests occur in fields; population densities may reach treatable levels; and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure.

[14] These pests are not key pests and are not present at damaging levels in most fields each year, but are occasional pests that may be present in a few fields each year, or may be occur at damaging levels in most fields at infrequent intervals (e.g. every 3-5 years).

Activity Tables for Alfalfa Seed for Montana and Wyoming

Cultural Activities Profile for Alfalfa Seed in Montana and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back[1]			----	-------	----							
Irrigation[2]				-------	-------	------	-------	-------	-------	----		
Fertilization[3]		---	-------					-------	-------	-------		
Cultivation[4]				-------						-------	----	
Harvest[5]								---	-------	----		
Planting[6]			-------	-------				-------	----			

Crop Monitoring Profile for Alfalfa Seed in Montana and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring			----		------	-------	-------	-------				
Weed monitoring			----	-------	-------				-------	-------		
Monitor soil moisture				-------	------	-------	-------	-------				

Pest Management Activities for Alfalfa Seed in Montana and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.						-------	-------	-------	---			
Miticide app.							-------	---				
Herbicide app.			-------	-------	-------	----				-------	---	

Pollinator Management Activities Profile for Alfalfa Seed in Montana and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Overwinter bees[7]	---	------	-------	-------					-------	-------	-------	-------
Incubate bees for release[8]					-------	------	---					
Move bee shelters to field[8]					-------	------	----					
Move bees into field[9]						------	----					
Move bees to overwintering sites[10]									-------	-------	---	

Seasonal Pest Occurrence for Alfalfa Seed in Montana and Wyoming[11]

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Alfalfa aphid				----	--------	--------	--------	---				
Alfalfa weevil					----	-------	----					
Armyworm/cutworms[12]			-------	--------	--------							
Blue alfalfa aphid				----	-------	-------	-------	---				
Cowpea aphid[12]						--------						
Grasshoppers[12]					----	--------	--------					
Loopers[12]							--------	----				
Lygus						-------	-------	-------				
Pea aphid					-------	-------	-------	---				
Spotted alfalfa aphid						-------	-------	---				

Spider mites							--------	---				
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual sowthistle				--------	--------	--						
Canada thistle				--------	--------	--			----	--------		
Common lambsquarters				--------	--------	--						
Common mallow				--------	--------	--						
Dodder				-----	-------	--------	--------	--------	----			
Field bindweed				--------	--------	--			--------	--------		
Grasses				--------	--------							
Kochia				--------	--------	--						
Mustards				--------	--------	--						
Nightshades				--------	--------	--						
Pigweed, redroot				--------	--------	--						
Prickly lettuce				--------	--------	--						
Sweet clover							--------	--------				
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers			--------	--------	--------	----				--------	-----	

[1] Set back is a cultural practice conducted using rotary mowers, swathers, roto-beaters, discs, etc. to set the crop back; i.e. delay bloom to coincide with pollinator release in June.

[2] 50 - 65% of the acreage is gravity irrigated and less than 10% is irrigated with a center pivot (sprinkler irrigation). Workers do not need to enter field.

[3] For the large majority of the acreage, fertilizations operations are contracted to custom applicators.

[4] Cultivations for weed control or set back are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 2-3 year contracts, and hence more frequent planting.

[7] Not a field activity. Included for informational purposes only.

[8] Not a continuous activity. Shelters are moved into fields to receive pollinators and left until the end of the season.

[9] As for shelters, this is not a continuous activity. Bees are moved into shelters and left until removed in the fall.

[10] Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

[11] Indicates periods when pests occur in fields; population densities may reach treatable levels; and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure.

[12] These pests are not key pests and are not present at damaging levels in most fields each year, but are occasional pests that may be present in a few fields each year, or may be occur at damaging levels in most fields at infrequent intervals (e.g. every 3-5 years).

Activity Tables for Alfalfa Seed for the Columbia Basin of Washington and Oregon

Cultural Activities Profile for Columbia Basin Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back[1]				-------	-------							
Irrigation[2]				-------	-------	------	-------	-------	-------	----		
Fertilization[3]			-------					-------	-------			
Cultivation[4]				----	-------	----			----	----		
Harvest[5]								-------	-------	----		
Planting[6]		---	-------	-------				-------	-------			

Crop Monitoring Profile for Columbia Basin Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring			----	-------	------	-------	-------	-------	-------	-------		
Weed monitoring			-------	-------	-------	-------	-------		-------	-------		
Monitor soil moisture					---	-------	-------	---				

Pest Management Activities for Columbia Basin Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.			---	-------	-------	-------	-------	----	---	-------	-------	
Miticide app.							-------	-------				
Herbicide app.		----	-------	-------	-------	-------	----	---	-------	-------	---	

Pollinator Management Activities Profile for Columbia Basin Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Overwinter bees[7]	---	------	-------	-------					-------	-------	-------	-------
Incubate bees for release[8]					-------	------	---					
Move bee shelters to field[8]				---	-------	------	----					
Move bees into field[9]						------	-------					
Move bees to overwintering sites[10]								---	-------	-------		

Seasonal Pest Occurrence for Alfalfa Seed in the Columbia Basin of Washington State[11]

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Alfalfa aphid			--------	--------	--------	--------	--------	--------	--------	--------		
Alfalfa weevil			--------	--------	--------							
Armyworm/cutworms[12]			----	--------	--------	--------	--------	--------	--------			
Blue alfalfa aphid			--------	-------	-------	-------	-------	-------				
Cowpea aphid									--------	--------	--------	
Grasshoppers[12]							--------	--------				
Loopers[12]						----	--------	--------				
Lygus				-------	-------	-------	-------	-------	-------			
Pea aphid			-------	-------	-------	-------	-------	-------	--------	--------		

Spider mites							----	--------	----			
Spotted alfalfa aphid					----	-------	-------	-------	--------	--------	-----	
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual sowthistle			----	--------	--------							
Canada thistle		-----	-------	--------	--------	--------	--------	--------	-------	--------	--------	
Common lambsquarters			----	--------	--------							
Common mallow			----	--------	--------							
Dodder					----	--------	--------	--------	--------			
Grasses			----	--------	--------	--------	--------	--------	-------	--------	-----	
Kochia			----	--------	--------	--------	--------	--------	--------	--------	--------	
Mustards		----	------	--------	--------			----	--------	--------	-----	
Nightshades			----	--------	--------	--------	--------					
Pigweed, redroot			----	--------	--------							
Prickly lettuce		-----	-------	--------	--------			----	--------	--------	--------	
Sweet clover						--------	--------	--------				
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers		--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	
Mice			--------	--------	--------	--------	----					

[1] Set back is a cultural practice conducted using rotary mowers, swathers, roto-beaters, discs, etc. to set the crop back; i.e. delay bloom to coincide with pollinator release in June.

[2] 60% of the acreage is furrow irrigated and 40% is irrigated with a center pivot (sprinkler irrigation). Workers do not need to enter field.

[3] For the large majority of the acreage, fertilizations operations are contracted to custom applicators.

[4] Cultivations for weed control or set back are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 2-3 year contracts, and hence more frequent planting.

[7] Not a field activity. Included for informational purposes only.

[8] Not a continuous activity. Shelters are moved into fields to receive pollinators and left until the end of the season.

[9] As for shelters, this is not a continuous activity. Bees are moved into shelters and left until removed in the fall.

[10] Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

[11] Indicates periods when pests occur in fields; population densities may reach treatable levels; and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure

[12] These pests are not key pests and are not present at damaging levels in most fields each year, but are occasional pests that may be present in a few fields each year, or may be occur at damaging levels in most fields at infrequent intervals (e.g. every 3-5 years).

Activity Tables for Alfalfa Seed for the Walla Walla Valley of Washington State

Cultural Activities Profile for Walla Walla Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back[1]				-------	-------							
Irrigation[2]			-------	-------	-------					-------	-------	-------
Fertilization[3]			-------									
Cultivation[4]				----	------	----			----	-------		
Harvest[5]								-------	-------	----		
Planting[6]		---	-------	-------				-------	-------			
Flaming		-------	-------									

Crop Monitoring Profile for Walla Walla Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring			----	-------	------	-------	-------	-------	-------	-------		
Weed monitoring			-------	-------	-------	-------	-------		-------	-------		
Monitor soil moisture			-------	-------	-------	-------						

Pest Management Activities for Walla Walla Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.			---	-------	-------	-------	-------	----	---	-------	-------	
Miticide app.							----	----				
Herbicide app.	-------	------	-------	-------	-------	Spot Spray		---	-------	-------	-------	-------

Pollinator Management Activities Profile for Walla Walla Alfalfa Seed

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Overwinter bees[7]	---	------	-------	-------					-------	-------	-------	-------
Incubate bees for release[8]					-------	------	---					
Move bee shelters to field[8]					-------	------	----					
Move bees into field[9]						------	-------					
Move bees to overwintering sites[10]									----	----		

Seasonal Pest Occurrence for Alfalfa Seed in the Walla Walla Valley of Washington State[11]

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Alfalfa aphid			--------	--------	--------	--------	--------	--------	--------	--------		
Alfalfa weevil			--------	--------	--------							
Armyworm/cutworms[12]			----	--------	--------	--------	--------	--------	--------			
Blue alfalfa aphid			--------	-------	-------	-------	-------	-------				
Cowpea aphid									--------	--------	--------	
Grasshoppers[12]							--------	--------				
Loopers[12]						----	--------	--------				
Lygus				-------	-------	-------	-------	-------	-------			

Pea aphid			-------	-------	-------	-------	-------	-------	--------	--------		
Spider mites							----	--------	----			
Spotted alfalfa aphid					----	-------	-------	-------	--------	--------	-----	
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual sowthistle			----	--------	--------							
Canada thistle		-----	-------	--------	--------	--------	--------	--------	-------	--------	--------	
Common lambsquarters			----	--------	--------							
Common mallow			-------	--------	--------	--------		--------	--------			
Dodder					----	--------	--------	--------	--------			
Field bindweed			----	--------	--------				----	--------		
Grasses			----	--------	--------	--------	--------	--------	-------	--------	-----	
Kochia			----	--------	--------	--------	--------	--------	--------	--------		
Mustards		----	--------	--------	--------			----	--------	--------	-----	
Nightshades			-------	--------	--------	--------						
Pigweed, redroot			----	--------	--------							
Prickly lettuce		-----	-------	--------	--------			---	--------	--------	--------	
Sweet clover						--------	--------	--------				
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers		--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	
Mice			--------	--------	--------	--------	----					

[1] Set back is a cultural practice conducted using rotary mowers, swathers, roto-beaters, discs, etc. to set the crop back; i.e. delay bloom to coincide with pollinator release in June.

[2] 100% of the acreage is irrigated with handlines (sprinkler irrigation). Workers do not need to enter field.

[3] For the large majority of the acreage, fertilizations operations are contracted to custom applicators.

[4] Cultivations for weed control or set back are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 2-3 year contracts, and hence more frequent planting.

[7] Not a field activity. Included for informational purposes only.

[8] Not a continuous activity. Shelters are moved into fields to receive pollinators and left until the end of the season.

[9] As for shelters, this is not a continuous activity. Bees are moved into shelters and left until removed in the fall.

[10] Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

[11] Indicates periods when pests occur in fields; population densities may reach treatable levels; and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure.

[12] These pests are not key pests and are not present at damaging levels in most fields each year, but are occasional pests that may be present in a few fields each year, or may be occur at damaging levels in most fields at infrequent intervals (e.g. every 3-5 years).

Activity Tables for Alfalfa Seed in the Central Valley of California

(dates for the Imperial Valley may vary)

Cultural Activities Profile for Alfalfa Seed in the Central Valley of California

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Clip back[1]				---								
Irrigation[2]			-------	-------	-------	------	-------	---	---	----		
Fertilization[3]	---	-------							---	-------	-------	---
Cultivation[4]				-------					-------			
Harvest[5]							----	-------	---			
Planting[6]	---	-------							---	-------	-------	---

Crop Monitoring Profile for Alfalfa Seed in the Central Valley of California

ACTIVITY[7]	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring				---	------	-------	-------	-------				
Weed monitoring		---	-------	-------	-------	-------	-------	-------				
Monitor soil moisture[8]			---	-------	-------	-------	------	---				

Pest Management Activities for Alfalfa Seed in the Central Valley of California

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.					-------	-------	-------	----				
Miticide app.						---	-------	---				
Herbicide app.	-------	-------	-------	-------	----						----	-------

Pollinator Management Activities Profile

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Move bees into field[9]					-------	------	-------					

Seasonal Pest Occurrence for Alfalfa Seed in the Central Valley of California[10] (dates for the Imperial Valley may vary)

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Alfalfa aphid				--------	--------	--------	--------	--------				
Alfalfa weevil			--------	----								
Armyworm/cutworms[11]						--------	--------					
Blue alfalfa aphid				-------	-------	-------	-------	-------				
Lygus[12]				----	-------	-------	-------	-------				
Pea aphid[13]				-------	-------	-------	-------	-------				
Spider mites						---	-------	----				
Spotted alfalfa aphid				-------	-------	-------	-------	-------				
WEEDS[14]	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual sowthistle		---------	--------	--------	--------	--------	----					
Canada thistle				----	--------	--------	--------	--------				
Common lambsquarters			----	--------	--------	--------	--------					
Common mallow	-------	---------	--------						--------	--------		
Dodder	-------	--------	--------	--------	--------	--------	--------	--------	--------			
Field bindweed		---------	-------	--------	--------	--------	--------	--------	-------			
Grasses		----	-------	--------	--------	--------	-----					
Kochia			----	--------	--------	--------	--------	--------	----			

Mustards	-------	---------	-------									
Nightshades			----	--------	--------	--------	----					
Pigweed, redroot			----	--------	--------	--------	--------					
Prickly lettuce		---------	-------	--------	--------	--------	---					
Sweet clover		-----	-------	--------	--------	--------	--------	-----				
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers		-------	--------	--------	--------	--------	----			--------	--------	
Horned larks		---------										

[1] Clip-back is a cultural practice conducted using rotary mowers or swathers to set the crop back; i.e. delay bloom to coincide with pollinator release in June.

[2] 100% of the acreage is gravity irrigated; in most cases, siphon tubes are used to move water from irrigation ditches bordering the field into furrows that run downhill the length of the field. Grated pipe can also be used to deliver water to the field. In some locations, water is pumped directly onto the field and allowed to flood a basin. Workers only enter field margins for short term with proper protective equipment.

[3] Fertilization is not common, but when necessary is done prior to planting. For the majority of the acreage, fertilizations operations, if performed, are contracted to custom applicators.

[4] Cultivations for weed control or thinning are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 2-3 year contracts, and hence more frequent planting.

[7] Workers enter fields for a short period of time to check field conditions with respect to pest and moisture conditions. Proper protective equipment is used.

[8] This is done by observation from the field margins.

[9] This is not a continuous activity. Bees are moved into hives and left until removed in the fall. Sometimes new bees are moved in mid-pollination.

[10] Indicates periods when pests occur in fields; when population densities may reach treatable levels, and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure, and during dormancy in the winter months.

[11] These pests are not key pests and are not present at damaging levels in most fields each year, but are occasional pests that may be present in a few fields each year, or may be occur at damaging levels in most fields at infrequent intervals (e.g. every 3-5 years).

[12] Lygus adults can be found in alfalfa seed fields all year long, but they are only controlled during pollination and seed maturation.

[13] Aphids are rarely, if ever, treated due to host plant resistance.

[14] Weeds are often treated pre-emergence or at seedling stages. If not controlled then, the problem lasts throughout the season and is dealt with by field crews or avoidance of weedy areas at harvest.

Activity Tables for Red (Perennial) Clover Seed in Western Oregon

Cultural Activities Profile for Red Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Flailing[1]					-------	----						
Irrigation	Clover seed in western Oregon is not irrigated											
Fertilization	Little to no fertilization; lime added pre-plant for pH adjustment											
Cultivation	Cultivation not practiced in western Oregon clover seed production											
Harvest[2]								---	-------			
Planting[3]			-------	-------					-------	-------		

Crop Monitoring Profile for Red Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring [4]	-------	-------	-------	-------			-------		-------	-------	-------	-------
Weed monitoring	-------	-------	-------	-------							-------	-------
Monitor soil moisture	Soil moisture is not monitored in western Oregon clover seed production											

Pest Management Activities for Red Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.	-------	-------	-------	-------			-------				-------	------
Fungicide app[5].			-------	-------					-------	-------		
Herbicide app.	-------	-------	-------									-------

Pollinator Management Activities Profile for Red Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Move bees into field[6]					-------	------	-------					
Move bees out of the field[7]								-------	-------	-------		

Seasonal Pest Occurrence for Red (Perennial) Clover Seed in Western Oregon[8]

INSECTS	J	F	M	A	M	J	J	A	S	O	N	D
Clover seed weevil[9]							--------					
Crown/root borer	No chemical controls for this pest. Present all year, with populations building to damaging levels beginning in the 2nd year of production.											
Pea aphid							--------					
Slugs	-------	---------	--------	--------							--------	--------
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Anthracnose			-------	--------					--------	--------		
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual ryegrass	-------	---------	--------									--------
Annual sowthistle	-------	---------	--------									--------
Canada thistle	-------	---------	--------									--------
Dodder	-------	---------	--------				spot spray					--------
Grasses/ Vol. Grain	-------	---------	--------									--------
Groundsel	-------	---------	--------									--------

Mayweed	--------	--------	--------									--------
Mustards	--------	--------	--------									--------
Perennial ryegrass	--------	--------	--------									--------
Prickly lettuce	--------	--------	--------									--------
Quackgrass	--------	--------	--------									--------
Vetch	--------	--------	--------									--------
Wild carrot	--------	--------	--------									--------
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Canada Geese	--------	--------	--------							--------	--------	--------
Gophers	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Voles	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

1 Forage is flailed at early bloom and is usually taken for forage harvest; occasionally forage is left in the field.

2 Harvest is conducted by swathing followed by combining. No hand labor is involved.

3 Hand labor is not involved.

4 Scouting for slugs in new fall plantings, and for aphids pre- to early-bloom.

5 Fungicide seed treatment used at planting.

6 This is not a continuous activity. Bees are moved into hives and left until removed in the fall. Honeybees are brought in by private industry or bee contractors. Bumblebees are naturally occurring.

7 Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

8 Indicates periods when pests occur in fields; population densities may reach treatable levels, and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table.

9 Occasional pest only.

Activity Tables for Crimson (Annual) Clover Seed in Western Oregon

Cultural Activities Profile for Crimson Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back	No set back or flailing is done in crimson clover											
Irrigation	Clover seed in western Oregon is not irrigated											
Fertilization	Little to no fertilization; lime added pre-plant for pH adjustment											
Cultivation	Cultivation not practiced in western Oregon clover seed production											
Harvest[1]						------						
Planting[2]									-------	-------		

Crop Monitoring Profile for Crimson Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring	-------	-------								-------	-------	-------
Weed monitoring	-------	-------	-------	-------							-------	-------
Monitor soil moisture	Soil moisture is not monitored in western Oregon clover seed production											

Pest Management Activities for Crimson Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.	-------	-------								-------	-------	-------
Fungicide app.[3]	-------	-------	-------	-------	-------				-------	-------		
Herbicide app.	-------	-------	-------	-------							-------	-------

Pollinator Management Activities Profile for Crimson Clover Seed in Western Oregon

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Move bees into field	Pollinator bees are not utilized for the production of crimson clover seed											
Move bees out of the field												

Seasonal Pest Occurrence for Crimson (Annual) Clover Seed in Western Oregon[4]

INSECTS	J	F	M	A	M	J	J	A	S	O	N	D
Slugs	-------	---------								--------	--------	--------
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Anthracnose[5]									--------	--------		
Sclerotinia (white mold)	-------	---------	--------	--------	--------							
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual ryegrass	-------	---------	--------									--------
Annual sowthistle	-------	---------	--------									--------
Canada thistle	-------	---------	--------									--------
Dandelion	-------	---------	--------									--------
Dodder	-------	---------	--------				spot spray					--------
Grasses/ Vol. Grain	-------	---------	--------									--------
Groundsel	-------	---------	--------									--------
Mayweed	-------	---------	--------									--------
Mustards	-------	---------	--------									--------

Perennial ryegrass	--------	--------	--------									--------
Prickly lettuce	--------	--------	--------									--------
Quackgrass	--------	--------	--------									--------
Vetch	--------	--------	--------									--------
Wild carrot	--------	--------	--------									--------
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Canada Geese	--------	--------	--------							--------	--------	--------
Gophers	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

[1] Harvest is conducted by swathing followed by combining. No hand labor is involved.

[2] Hand labor is not involved.

[3] Ipridione (Rovral) is the only foliar fungicides applied, and it is only directed at sclerotinia control. Only two applications of Rovral are permitted, and those are usually done earlier in the season (i.e., beginning in February)

[4] Indicates periods when pests occur in fields; population densities may reach treatable levels, and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table.

[5] Fungicide seed treatment used at planting.

Activity Tables for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only), Wyoming

Cultural Activities Profile for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only) and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Set back[1]			-------	-------	-------							
Irrigation[2]				-------	-------	------	-------	-------	-------	----		
Fertilization[3]		-------	-------					-------	-------	-------		
Cultivation[4]				-------	-------	------						
Harvest[5]									-------	----		
Planting[6]			-------	-------				-------	-------			

Crop Monitoring Profile for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only) and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pest & beneficial insect monitoring				-------	------	-------	-------	-------				
Weed monitoring			-------	-------	-------	-------	-------		-------	-------		
Monitor soil moisture				-------	------	-------	-------	-------	-------	---		

Pest Management Activities for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only) and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Insecticide app.				-------	-------	-------	-------	-------				
Miticide app.							-------	-------				
Herbicide app.			-------	-------							-------	

Pollinator Management Activities Profile for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only) and Wyoming

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Move bees into field[7]					-------	------	-------					
Move bees out of the field[8]								-------	-------	-------		

Seasonal Pest Occurrence for Red Clover Seed in the Treasure Valley, Columbia Basin (WA only) and Wyoming[9]

INSECTS	J	F	M	A	M	J	J	A	S	O	N	D
Clover seed weevil[10]						--------						
Cutworms			--------	--------								
Pea aphid					-------	-------	-------	------				
Spider mites							-------	--------				
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Annual sowthistle				--------	--------							
Canada thistle				--------	--------				----	--------		
Common lambsquarters				--------	--------							
Common mallow				--------	--------							

Dodder				-------	-------	--------	--------	--------	--------			
Field bindweed				--------	--------				--------	--------		
Grasses/Grain				--------	--------							
Groundsel	-------	---------									--------	--------
Kochia				--------	--------	Hand weeding						
Lady's thumb				--------	--------	--------						
Mustards				--------	--------	Hand weeding						
Nightshades				--------	--------							
Pigweed, redroot				--------	--------	Hand weeding						
Prickly lettuce				--------	--------	Hand weeding						
Sweet clover							--------	--------				
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Gophers	------	---------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

[1] Set back is a cultural practice conducted using rotary mowers, swathers, roto-beaters, discs, etc. to set the crop back; i.e. delay bloom to coincide with pollinator release in June. Set back is not done during the first year of production.

[2] 80% of the clover seed acreage is gravity irrigated and 20% is sprinkler irrigated. Workers do not enter the field if herbicides have been applied.

[3] Fertilizer is applied September through August for fall seeded clover and February through March for spring seeded clover. Fertilizer is re-applied during the second year of production in September and October. For the large majority of the acreage, fertilizations operations are contracted to custom applicators.

[4] Cultivations for weed control or set back are conducted in the spring prior to canopy closure or in the fall after harvest.

[5] Harvest is conducted by either directly combining, or by swathing followed by combining. No hand labor is involved.

[6] Planting is using tractors and attached cultivating/planting implements. Hand labor is not involved. 5-year rotations were once common, but the trend has been towards shorter, 1-2 year contracts (occasionally a 3 year contract), and hence more frequent planting.

[7] This is not a continuous activity. Bees are moved into hives and left until removed in the fall. Bees are brought in by private industry or bee contractors.

[8] Conducted once per field to remove bees from fields in the fall. May occur pre-, or post-harvest.

[9] Indicates periods when pests occur in fields; population densities may reach treatable levels, and when field activities are likely. Does not indicated mere presence of pests in field, i.e. perennial weeds and some insect pests may be found in fields all year, but management activities only occur as indicated in table. Most weed management activities occur in the spring prior to canopy closure.

[10] Occasional pest only.

Example Lygus Bug Management Plan for California

SCOUTING RECOMMENDATIONS: Scout fields twice weekly beginning early season and continuing until the crop begins to dry down in preparation for harvest. Lygus populations are determined from counts that consist of two sweeps at each of 5 or 10 locations throughout the field. Each sweep covers an arc of 180º with the net striking the top 8-10 inches of the plants. In general, all counts from a field are averaged and treatment decisions are based on this *average* population (insects per sweep) but it is prudent to delay treatment until egg hatch is complete. Occasionally it is practical to treat only portions of a field. By continuous monitoring of predators and pests in the field, accurate assessments can be made that will result in reduced use of chemicals and improved timing of applications.

EARLY SEASON (Vegetative Growth/Pre-Bloom)			**MID-SEASON (during Bloom)**	**LATE SEASON (2nd and 3rd flushes of bloom for most chemicals; post-bloom for Monitor or Supracide)**
Stage I: Carbamates	Stage II: Organophosphates		Stage III: Pyrethroids	Stage IV: OP's/ Carbamates/Mixtures
TEMIK may be applied prior to row closure or second crop irrigation, whichever occurs later. It is taken up by the plant following subsequent irrigation or rainfall, and does not become effective for lygus control until that time.	If lygus are present, apply **MONITOR** or **SUPRACIDE** up to 3 days prior to placing bees in or around the field. Do not make more than 1 pre-bloom application per crop season. If Temik has been applied, higher lygus thresholds may be tolerated.	To control low Lygus populations that may appear in seed fields before Temik is activated, apply **MSR** for nymphs, **DIBROM** for adults *only* if Monitor or Supracide has not been used previously.	Apply **CAPTURE**, **POUNCE**, or **WARRIOR** if lygus counts exceed established thresholds.	Apply **LANNATE**, **LORSBAN**, or **CARZOL** if lygus counts average 10-15 per sweep. Once bees are removed, apply **MONITOR** or **SUPRACIDE** if lygus counts exceed thresholds; thresholds are higher later in the season.

Example Lygus Bug Management Plans for the Pacific Northwest

SCOUTING RECOMMENDATIONS: Scout fields at least once weekly beginning early season and continuing until the crop begins to dry down in preparation for harvest. Alternatively begin early season sampling for lygus bugs when 272º degree days have accumulated. Sample once per week thereafter. lygus populations are determined from counts that consist of 5 sweeps at each of at least 5 locations throughout the field. Each sweep covers an arc of 180º with the net striking the top 8-10 inches of the plants. All counts from a field are averaged and treatment decisions are based on this *average* population (insects per sweep) but it is prudent to delay treatment until egg hatch is complete. Occasionally it is practical to treat only portions of a field. By continuous monitoring of predators and pests in the field, accurate assessments can be made that will result in reduced use of chemicals and improved timing of applications.

Selective Management Plan (preserves predators)		
EARLY SEASON (Vegetative Growth/Pre-Bloom)	**MID-SEASON (during Bloom)**	**LATE SEASON (2nd and 3rd flushes of bloom for most chemicals; post-bloom for Monitor or Supracide)**
If alfalfa weevil numbers do not exceed established threshold and lygus predators are present, control lygus bugs in with a selective insecticide such as **Metasystox-R**, timed to catch the first hatch of lygus bug nymphs in late May or early June. Treat before lygus bugs develop into 4th instar nymphs but when lygus hatch is nearly complete. Metasystox-R will not provide good control of late instar lygus nymphs and adults. If lygus predators are not present a less selective pesticide such as **Capture, Warrior, Lorsban, Dimethoate or Supracide** can be used with minimal disruption of predator populations.	Apply insecticides only during late evening or night. There are few effective lygus compounds that are safe to both pollinators and natural enemies. If **Metasystox-R** has not been used prebloom it can be used here but may not provide good control of late instar lygus nymphs. If **Capture** has not been used early it can be used effectively here but will reduce predator numbers; it should not be used if spider mites are present and will be treated with Comite. Other compounds that will control lygus but are not compatible with natural enemies include Dibrom, Carzol, and malathion (ULV @ low rate).	If lygus bug numbers are below threshold, numbers of damsel bugs and big-eyed bugs are twice the number of lygus, and late instar lygus numbers are not increasing, a lygus treatment may not be justified. After most of the seed has hardened in the pods (mid-to late August). The lygus threshold should be raised later in the season.

Semi Selective Management Plan (less predator preservation)		
EARLY SEASON (Vegetative Growth/Pre-Bloom)	**MID-SEASON (during Bloom)**	**LATE SEASON (2nd and 3rd flushes of bloom for most chemicals; post-bloom for Monitor or Supracide)**
If alfalfa weevil numbers do not exceed established thresholds and lygus predators are present, control lygus bugs in with a less selective insecticide such as **Furadan Supracide, Capture, Warrior, Lorsban, or Cygon**, timed to catch the first hatch of lygus bug nymphs in late May or early June. Treat before lygus bugs develop into 4th instar nymphs but when lygus hatch is nearly complete. Earlier treatment will be less disruptive of predator activity than late treatments.	Apply insecticides only during late evening or night. There are few effective lygus compounds compounds that are both safe to pollinators and natural enemies. If **Metasystox-R** has not been used prebloom it can be used here but may not provide good control of late instar lygus nymphs. If **Capture** has not been used early it can be used effectively here but will reduce predator numbers. Other compounds that will control lygus but are not compatible with natural enemies, include Dibrom, Carzol, and malathion (ULV @ low rate).	After pollinator activity has ceased, a clean-up spray can be applied to protect the developing seed: **Lannate**, **Lorsban**, **Carzol, Monitor** or **Supracide** are all options**. Lannate and Carzol** are less disruptive to predator populations. **Metasysox R** is least disruptive to predators but if it has been used earlier, it should not be used here to prevent resistance development. After most of the seed has hardened in the pods (mid-to-late August) the lygus threshold should be raised later in the season.

Nematode Management on Alfalfa and Clover Seed

This table is a compilation of information concerning the efficacy of various compounds and practices on alfalfa and clover seed insects. They are not an indication of registration for specific pests although we have indicated their general registration

Management Tool	Northern Root-Knot Nematode	Columbia Root-Knot Nematode	Alfalfa Stem Nematode	Lesion Nematode	Southern Root-Knot Nematode	Comments
Fumigants						
1,3-dichloropropene (Telone C-15)	NU	NU	NU	NU	NU	Too expensive.
metam-sodium (Metam)	NU	NU	NU	NU	NU	Too expensive.
IPM and Cultural Controls						
Adequate fertilization	G	G	G	G	G	
Adequate irrigation	G	G	G	G		
Green manures	G	G	X	G	G	
Plant resistant varieties	G	F	G	?		
Archer	G	F	E			
Other varieties	G	F	E		E*	*Non-dormants.
Pre-plant cultivation	F	F	F	F	F	Bury by plowing.
Pre-plant burning			F			
Rotate to non-host crops	P	P	F	P	P	
Suppression of weed hosts	P	P		P	P	

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, NU=not used, X=no rating given.

Weed Management on Alfalfa and Clover Seed

This table is a compilation of information concerning the efficacy of various compounds and practices on alfalfa and clover seed weeds. They are not an indication of registration for specific pests although we have indicated their general registration on

	Annuals																				Perennials												
Management Tool	Annual Ryegrass	Annual Sowthistle	Blue Mustard	Common Lambsquarters	Downy Brome	Grasses	Groundsel	Hairy Nightshade	Kochia	Mayweed	Pigweed	Prickly Lettuce	Russian Thistle	Sunflower	Vetch	Volunteer Grains	White Cockle	Wild Mustard	Wild Oats	Yellow Starthistle	Canada Thistle	Common Mallow	Common Yarrow	Dandelion	Dodder	Perennial Ryegrass	Quackgrass	Russian Knapweed	Volunteer Alfalfa	Volunteer Sweet Clover	Wild Carrot (Biennial)	Yellow Nutsedge	Comments
Registered Herbicides																																	
2,4-DB (Butyrac)		P		P-G	N			G	P-F	P	P	P	P	G		N		F-G	N		P	P		P	P		N				P	N	
benefin (Balan DF)		P	P	G-E	E			P	G-E	P	G	P	G-E	P				P	F					P	P		P			F-G			
bentazon (Basagran) WA, OR		P		P-F	G			G-E	P	P	P	P	G-E	E							G	F										G-E	Common mallow seedlings=G.
bromoxynil (Buctril)		F-G	F-G	G	P			G	E	F-G	P	F	G	E		P		G	P		P			P	P		P					N	
clethodim (Select)	E	N	N	N	P-G			N	N	N	N	N	N	N		G-E		N	G		N	N	N	N	N	E	F	N	N	N	N	N	Quackgrass in western OR=G
diuron (Karmex, Diuron)		G-E	G	E	F	F-P		F-G	E		G-E	E	G-E	F		P-F		E	P						P		P					F	
EPTC (Eptam)		P	P	G	G-E			G	P	F-G	F-G	P	P	P		G		P	G					P	P		F-G					G	
ethalfluralin (Sonalan)					F-G			F-P								F			P-F								P					N	
fluazifop (Fusilade)		N	N	N				N	N	N	N	N	N	N		G-E		N	G-E		N	N	N	N	N		F	N	N	N	N	N	
glyphosate (Roundup)																																	
gramaxone (Paraquat)		E		E	E			E	G	G-E		E	E	E		E			F-G					F			F						
hexazinone (Velpar)																																	
imazamox (Raptor)		P-F		G	G			G-E	G	P	G	P	F-G	E		F-G		E	G		P	P-G	P	P	F-G		P	P			P	P-F	Common mallow seedlings=G. Multiple applications needed for dodder control.

Efficacy Rating Symbols: E=Excellent (90-100% control); G=Good (80-90% Control); F=Fair (70-80% Control); P=Poor (<70% Control); ?=No Data; N=No control because not the right chemistry; Blank=Efficacy Unknown.

Management Tool	Annuals																				Perennials												Comments
	Annual Ryegrass	Annual Sowthistle	Blue Mustard	Common Lambsquarters	Downy Brome	Grasses	Groundsel	Hairy Nightshade	Kochia	Mayweed	Pigweed	Prickly Lettuce	Russian Thistle	Sunflower	Vetch	Volunteer Grains	White Cockle	Wild Mustard	Wild Oats	Yellow Starthistle	Canada Thistle	Common Mallow	Common Yarrow	Dandelion	Dodder	Perennial Ryegrass	Quackgrass	Russian Knapweed	Volunteer Alfalfa	Volunteer Sweet Clover	Wild Carrot (Biennial)	Yellow Nutsedge	
imazethapyr (Pursuit)		P		F	P			E	G	P	G	P	F	G		P		E	F		P	P-F		P	P-F		P				P	P-F	
metholachlor (Dual) SLN OR																																G	
MCPA amine (MCPA)		F-G					P					F-G			P						G			G									Clover seed only
metribuzin (Sencor)		G	G	E	G			P	G		G-E	E	F-G	F-G		P-F		E	F-G					P-F	P		P-F					F-G	
norflurazon (Zorial)				F-E	E			G	F-G		G							G			P			P	P								
oxyfluorfen (Goal)							P																										Not yet registered for clover seed; IR-4 pipeline
pendimethalin (Prowl)		P		P-F				P-F	P		F	P				P-F			F		P	P			G-E							N	
pronamide (Kerb)	E	P	F-G	G	E			G	F		P	P	G	P		G		G	F-G					P	F-G		G						
quizalofop (Assure)		N	N	N				N	N	N	N	N	N	N		G-E		N	G-E		N	N	N	N	N		F	N	N	N	N	N	
sethoxydim (Poast, Poast Plus)		N	N	N	P			N	N	N	N	N	N	N		G		N	G		N	N	N	N	N		F-G	N	N	N	N	N	
simazine (Simazine, Princep)																																	
terbacil (Sinbar)		E	P	E	E			E	G-E		F-G	E	G-E	G		F-G		E						F-G	P		F					F	
trifluralin (Treflan)		P	P	G-E	E			P	G-E		G	P	G-E	P		F-G		P	F					P	P		P						

Efficacy Rating Symbols: E=Excellent (90-100% control); G=Good (80-90% Control); F=Fair (70-80% Control); P=Poor (<70% Control); ?=No Data; N=No control because not the right chemistry; Blank=Efficacy Unknown.

Disease Management on Alfalfa and Clover Seed

This table is a compilation of information concerning the efficacy of various compounds and practices on alfalfa and clover seed diseases. They are not an indication of registration for specific pests although we have indicated their general registration

Management Tool	Alfalfa Mosaic Virus	Anthracnose	Aphanomyces	Bacterial Wilt	Crown Root Complex	Damping off and Seedling Blight (Fusarium)	Damping off and Seedling Blight (Pytophthora)	Damping off and Seedling Blight (Pythium)	Damping off and Seedling Blight (Rhizoctonia)	Downy Mildew	Fusarium Wilt	Pytophthora Root Rot	Rhizoctonia Stem Canker	Sclerotinia (white mold)	Stagonospora Root Rot	Verticillium Wilt	Comments
Seed Treatments																	
captan (Captan 400)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	
fludioxonil + metalaxyl (Maxim XL)	NU	NU	NU	NU	NU	P	NU	P	P	P	NU	NU	NU	NU	NU	NU	
metalaxyl (Allegiance FL)	NU	NU	NU	NU	NU	G	G	G	G	G	NU	NU	NU	NU	NU	NU	
metalaxyl (Apron XL LS)	NU	NU	NU	NU	NU	G	G	G	G	G	NU	NU	NU	NU	NU	NU	
metalaxyl-M (Ridomil Gold)	NU	NU	NU	NU	NU	G	NU	G	G	G	NU	NU	NU	NU	NU	NU	
thiabendazole (LSP)	NU	G-E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	w. Oregon clover seed only
Foliar Fungicides																	
ipridione (Rovral)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	NU	Crimson clover seed only
IPM and Cultural Controls																	
Aphid control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Appropriate irrigation	X	X	G	X	X	G	G	G	G	X	G	G	G	X	X	X	Over irrigation promotes stem canker
Avoid plant injury	X	X	X	X	G	X	X	X	X	X		X	X	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; X=no rating given; NU=Not used.

Management Tool	Alfalfa Mosaic Virus	Anthracnose	Aphanomyces	Bacterial Wilt	Crown Root Complex	Damping off and Seedling Blight (Fusarium)	Damping off and Seedling Blight (Pytophthora)	Damping off and Seedling Blight (Pythium)	Damping off and Seedling Blight (Rhizoctonia)	Downy Mildew	Fusarium Wilt	Pytophthora Root Rot	Rhizoctonia Stem Canker	Sclerotinia (white mold)	Stagonospora Root Rot	Verticillium Wilt	Comments
IPM and Cultural Controls, cont.																	
Certified seed	P (1)	E (2)	E (2)	E (2)	X	X	E (2)	X	X	X	E (2)	E (2)	X	G	X	E (2)	(1) Certified seed fields are in production a much shorter time. Virus builds up slowly, whereas fields of non-certified seed may be in production for over 10 years, so there is a higher virus incidence. (2) When planting certified seed, more likely to be
Deep plow	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Early cutting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Plant-resistant cultivars	NA	E	E	E	F	NA	E	NA	NA	NA	E	E	X	X	X	E	
Rotation to non-host crops	P	X	G	P	X	X	G	X	X	X	P	G	P	G	X	G	
Sanitation of equipment	X	?	X	X	X	X	X	X	X	X	X	X	X	X	X	?	
Soil fertility maintenance	X	X	X	G	X	X	G	X	X	X	G	G	X	X	X	G	
Weed management	X	X	X	X	X	X	X	X	X	X	X	X	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; X=no rating given; NU=Not used, NA = None available.

Insect Management in Alfalfa and Clover Seed

This table is a compilation of information concerning the efficacy of various compounds and practices on alfalfa and clover seed insects. They are not an indication of registration for specific pests although we have indicated their general registration

Management Tool	Alfalfa Caterpillar	Alfalfa Seed Chalcid	Alfalfa Weevil	Aphids (Pea, Blue Alfalfa and Alfalfa)	Aphid, Spotted Alfalfa	Armyworms	Blister Beetle (Adult)	Clover Crown/Root Borer	Clover Root Curculio	Clover Seed Weevil	Cutworms	Egyptian Alfalfa Weevil	Flea Beetle (Adult)	Grasshoppers	Loopers	Lygus Bugs	Pea Leaf Weevil	Slugs	Spider Mites	Webworm	Comments
Registered Insecticides																					
abamectin (Agri-Mek)																			G		Resistance concerns.
bifenthrin (Capture)			G	G	G					G	G					G			G		Causes mite and aphid flare-ups. Issues with resistance.
carbaryl (Sevin)											E			?							Causes mite flare-ups.
carbofuran (Furadan)			G	G												G					Three weeks control.
chlorpyrifos (Lorsban)			G	G	G					G	E	G			G	G			P		
diflubenzuron (Dimilin)														G							Good on small instars.
dimethoate (Dimethoate)			P	G	P									G		G					Better on small instars.
endosulfan (Endosulfan, Phaser)				G	G											F					
formetanate hydrochloride (Carzol)																G			G		Little residual. Expensive.
hexythiazox (Onager)																			G		Best on immatures. Resistance issues.
lambda-cyhalothrin (Warrior)			G	G	G	G			P		G	E		G	G	G			G	G	Causes mite and aphid flare-ups. Issues with resistance.
malathion (Malathion)				G		G													G		Ultra Low Volume (ULV) has 7-day residual (leafcutter bees).
metaldehyde (various)																		G			W.OR only
methidathion (Supracide)			G	F												F			?		
methomyl (Lannate)			G	F		G					?					F					
methyl parathion (Penncap-M, Methyl Parathion)			G	G		G										G					
pirimicarb (Pirimor)				G	p											P			P		Poor spotted aphid control.

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Efficacy Rating Symbols: E=Excellent (90-100% control); G=Good (80-90% Control); F=Fair (70-80% Control); P=Poor (<70% Control); ?=No Data; *=not a stand-alone practice.

Management Tool	Alfalfa Caterpillar	Alfalfa Seed Chalcid	Alfalfa Weevil	Aphid (Cowpea,Pea, Blue Alfalfa and Alfalfa)	Aphid, Spotted Alfalfa	Armyworms	Blister Beetle (Adult)	Clover Crown/Root Borer	Clover Root Curculio	Clover Seed Weevil	Cutworms	Egyptian Alfalfa Weevil	Flea Beetle (Adult)	Grasshoppers	Loopers	Lygus Bugs	Pea Leaf Weevil	Slugs	Spider Mites	Webworm	Comments
Registered Insecticides, cont.																					
naled (Dibrom)			G	G	F						G					G					
oxdemeton-methyl (MSR)				F-G												F			F		Best control of early instars.
permethrin (Ambush, Pounce)			G	G	G	G	G				G		G	G	G	G			G	G	Causes mite and aphid flare-ups. Issues with resistance.
phosmet (Imidan)			F	F								F					G				Warden, WA only; typically on new seedlings. Pea aphid only.
propargite (Comite)																			G		
pymetrozine (Fulfill)				P-F	P																
Sulfur DF																			F		
zeta-cypermethrin (Mustang)			G	G		G					G			G	G	G				G	Causes mite and aphid flare-ups. Issues with resistance.
IPM and Cultural Controls																					
Adequate fertilization				*	*				G		F										
Adequate irrigation				*	*				G		F								G		
Clip-back/set-back		*																	*		
Control volunteer alfalfa																					
Early cutting		G																			
Plant resistant varieties	P	P	P	E	E	P	P	P	G	P	P		P	P	P	P	P		P	P	
Pre-plant burning		G	G	G		G										G			G		
Pre-plant cultivation		G																			
Post-harvest cultivation			G											G							
Rotate to non-host crops								G	G		F										
Suppress weed hosts		F														*					

Efficacy Rating Symbols: E=Excellent (90-100% control); G=Good (80-90% Control); F=Fair (70-80% Control); P=Poor (<70% Control); ?=No Data; *=not a stand-alone practice.

Management Tool	Alfalfa Caterpillar	Alfalfa Seed Chalcid	Alfalfa Weevil	Aphids (Pea, Blue Alfalfa and Alfalfa)	Aphid, Spotted Alfalfa	Armyworms	Blister Beetle (Adult)	Clover Root Borer	Clover Root Curculio	Clover Seed Weevil	Cutworms	Egyptian Alfalfa Weevil	Flea Beetle (Adult)	Grasshoppers	Loopers	Lygus Bugs	Pea Leaf Weevil		Spider Mites	Webworm	Comments
Biological Controls																					
Bacillus thuringiensis			P			P-F					P				P-F						Can be good on small caterpillars.
Bathyplectes curculionis wasp			*																		
Beauvaria bassiana fungus																	*				
Generalist predators			*	*	*											*			*		
Nosema locustae														F							Can be effective on small instars.
Peristenus wasps																?					
Predatory mites																			P		

Efficacy Rating Symbols: E=Excellent (90-100% control); G=Good (80-90% Control); F=Fair (70-80% Control); P=Poor (<70% Control); ?=No Data; *=not a stand-alone practice.

Toxicity Ratings on Pollinators and Beneficials in PNW Alfalfa and Clover Seed

	Pollinators			Beneficials											
	AB	HB	LCB	BEB	DB	LW	LB	MPB	PM	PN	PW	S	SF	TF	TSS
Registered Insecticides															
carbaryl (Sevin)	1	1	1	G	G	G	G	G							
carbofuran (Furadan)	1	1	1	F-P	F-P	F-P	F-P	F-P				F-P			
chlorpyrifos (Lorsban)	1	1	1	F	F	ND	F	F	F	ND	ND	P	ND	ND	
dimethoate (Dimethoate)	1	1	1	F-P	F-P	F-P	F-P	F-P							
formetanate hydrochloride (Carzol)	3	2	3	F-P	F-P	F-P	F-P	F-P	P						
lambda-cyhalothrin (Warrior)	1	1	1	F-P	F-P	F-P	F-P	F-P	F-P						
malathion (Malathion)	1	1	1	F	F	F	P	F	P	F	F	F-P	P	F	
methomyl (Lannate)	1	1	1	P	P	ND	P	P	P	ND	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
n-methyl carbamate (Pirimor)	3	3	3	G	G	G	G	G							
oxdemeton-methyl (MSR)	3	2	2	F	F	F	F	F							
permethrin (Ambush, Pounce)	1	1	1	F-P	F-P	F-P	F-P	F-P							
phosmet (Imidan)	1	1	2												
Sulfur DF	4	4	4	G	G	G	G	G	F-P						
zeta-cypermethrin (Mustang)	1	1	1	P	P	P	P	P	P						
(24C) Insecticide Registration															
abamectin (Agri-Mek)	2	3	3	P	ND	ND	ND	P	P						
bifenthrin (Capture)	1	1	1	F-P	F-P	F-P	F-P	F-P	F-P						
diflubenzuron (Dimilin)	4	0	0	F	F	F	F-P	F	F						
endosulfan (Endosulfan, Phaser)	3	1	2	F-P	E-G	F-P	F-P	E	F-P			P			
hexythiazox (Onager)	4	4	4	G	G	G	G	G	F						

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

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).

E = Excellent survivability, G = Good survivability, F = Fair survivability and P = Poor survivability; ND=No Data; Blank=do not know.

	Pollinators			Beneficials											
	AB	**HB**	**LCB**	**BEB**	**DB**	**LW**	**LB**	**MPB**	**PM**	**PN**	**PW**	**S**	**SF**	**TF**	**TSS**
(24C) Insecticide Registration, cont.															
methidathion (Supracide)	1	1	1	F-P	F-P	F-P	F-P	F-P	F-P						
naled (Dibrom)	2	1	1	P	P	P	P	P	P						
propargite (Comite)	4	4	4	G	G	G	ND	F	F	ND	ND	ND	ND	ND	ND
pymetrozine (Fulfill)	3	3	3	G	G	G	G	G	G						
Seed Treatments															
captan (Captan 400)	N/A	N/A	N/A												
fludioxonil + metalaxyl (Maxim XL)	N/A	N/A	N/A												
metalaxyl (Allegiance FL)	N/A	N/A	N/A												
metalaxyl (Apron XL LS)	N/A	N/A	N/A												
metalaxyl (Ridomil Gold)	N/A	N/A	N/A												
thiram (Thiram 50 WP)	N/A	N/A	N/A												
Biological Insecticides															
Bacillus thuringiensis	4	4	4	E	E			E				E			
Biocontrols															
Nosema locustae	4	4	4												

AB=Alakai Bees, **HB**=Honeybees, **LCB**=Leafcutting Bees, **BEB**=Big-eyed bugs, **DB**=Damsel bug, **LW**=Lacewings (*Chrysopa* spp.), **LB**=Lady beetles (*Hippodamia convergens*), **MPB**=Minute pirate bugs (*Orius* spp.), **PM**=Predatory mites (*Acari: Phytoseiidae),* **PN**=Predatory nematodes, **PW**=Parasitic wasps (**I**chneumonidae, Braconidae, Chalcidae families), **S**=Spiders *(Erigone aletris, E. blaesa,* and *E. dentosa),* **SF**=Syrphid flies, **TF**=Tachinid flies, and **TSS**=Two-spotted stinkbug.

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).

E = Excellent survivability, G = Good survivability, F = Fair survivability and P = Poor survivability; ND=No Data; Blank=do not know.