Pest Management Strategic Plan
for
Processed Snap Beans
in
Oregon and Washington

Summary of a workshop held on
February 3, 2005
Salem, Oregon

Lead Author: Joe DeFrancesco
Editor: Sally O'Neal Coates

Contact Person:
Joe DeFrancesco, OSU Pest Management Specialist
(541) 737-0718
defrancj@science.oregonstate.edu

This project was sponsored by the Western Integrated Pest Management Center,
which is funded by the United States Department of Agriculture,
Cooperative State Research, Education and Extension Service.

Table of Contents

Work Group Members

Oregon

Nick Ebner, Grower
Tom Fesler, Grower
Jim Gill, Crop Consultant (Norpac Foods)
Andy Johnson, Crop Consultant (Harris-Moran Seed Co.)
Alan Kendell, Grower
Daniel McGrath, Oregon State University, Extension Service
Bob McReynolds, Oregon State University, Extension Service
Kurt Metzker, Crop Consultant (Truitt Foods)
Cindy Ocamb, Oregon State University, Plant Pathologist
Wayne Parker, Crop Consultant (National Frozen Foods)
Ed Peachey, Oregon State University, Weed Science
Jason White, Crop Consultant (National Frozen Foods)

Washington

Hollis Kiel, Crop Consultant (Harris-Moran Seed Co.)
Joe Wyffels, Crop Consultant (Grandview Foods)

Others in Attendance

Joe DeFrancesco, Oregon State University
Marilyn Dykstra, Pest Management Center, Agriculture and Agri-Food Canada
Sandra Halstead, EPA Region 10
Gina Koskela, Oregon State University

Workgroup Members Not In Attendance at Workshop

Glenn Fisher, Oregon State University, Research and Extension Entomology
Manuel Silveira, Crop Consultant (Norpac Foods)

Executive Summary

EPA is now engaged in the process of registering and re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA). EPA's regulatory focus on the organophosphate (OP), carbamate, and suspected 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 snap beans. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling certain registrations.

The processed snap bean industry is at risk of losing a number of essential chemicals critical for pest management. At the same time, a number of newer, unproven, low-risk chemistries are becoming available. The snap bean industry faces efficacy and economic uncertainties surrounding these shifts in control strategies. In addition, widespread reductions in funding have reduced or weakened the ability of land-grant university personnel to conduct field research and extension programs.

The Endangered Species Act (ESA) mandates that Federal agencies such as EPA consult with the National Oceanic and Atmospheric Administration (NOAA-Fisheries) if EPA takes an action that may affect threatened or endangered species. Recently, lawsuits have been filed against EPA stating that they failed to complete the consultation process. The result of one of these lawsuits is that mandatory no-spray buffer zones have been temporarily imposed for certain pesticides in threatened and endangered salmonid species habitat in Washington, Oregon, and California. Because of the number of consultations that must take place to satisfy the mandates of the ESA and because of the complexity of the process, it is expected that mandatory buffer zones from this lawsuit will remain in effect for several years. These buffer zones, whether planted to crops or abandoned to weeds, have the potential to act as pest reservoirs that will repeatedly infest neighboring crops. The total effect of ESA implementation is yet to be determined; however, it will clearly require new pest management strategies in the snap bean industry.

A cross-section of snap bean growers, researchers, Extension service personnel, industry representatives, and crop advisors from Oregon and Washington met for a full day in February 2005 to develop a Pest Management Strategic Plan that identifies the critical research, regulatory, and educational needs for their industry. This document is the result of that meeting.

Summary of the Most Critical Pest Management Needs in Oregon and Washington Processed Snap Beans

RESEARCH

- Identify a replacement for vinclozolin (Ronilan) fungicide for control of gray mold and white mold diseases.
  Vinclozolin, which is widely used and provides excellent control of these serious diseases, is scheduled to be cancelled for use in snap beans after the 2005 field season; the need to find a suitable replacement is critical.

- Identify new management tools for control of soil-borne insects.
  Current management options for control of seed corn maggot, symphylans, and wireworms rely heavily on organophosphate chemistries.

- Identify preemergence herbicides that are effective in managing hard-to-control weeds and/or weeds for which there is a low tolerance in the harvested bean crop.
  Needed are herbicides that are effective, fit into a snap bean production system, and have a mode of action that is different from currently registered herbicides.

- Identify new pesticides for diseases, insects, and weeds that are suitable alternatives to the currently registered broad-spectrum pesticides.
  Reduced risk and pest-specific pesticides have a better fit in an IPM program.

- Develop weather-based risk assessment models for diseases and insects.
  Pest outbreak predictions and assessing risk are important components for determining the need for, and timing of, control measures.

- Investigate chemical, cultural, and biological controls for slugs, and develop a risk assessment model.

REGULATORY

- Maintain current fungicide registrations and expedite registration of new fungicides.
  This applies to seed treatment fungicides as well as foliar-applied fungicides for white mold and gray mold control.

- Once identified by research, expedite the registration of new herbicides.

EDUCATION

- Inform growers of alternative gray mold and white mold management practices and timing of controls once vinclozolin registration is cancelled.

- Continue to educate growers about weed management strategies and preventing weed shifts.

- Continue to educate growers about fungicide chemical classes and the principles of resistance management.

- Impart to growers the information necessary to determine risk assessments for diseases and insects in their crop.

Production Facts

Together, in 2004, Oregon and Washington produced about 15% of the total processed snap bean crop in the United States.

Oregon ranks third in U.S. processed snap bean production. In 2004, Oregon produced 115,320 tons of snap beans for processing on 17,800 acres, with a value of $20.6 million. Snap bean production in Oregon occurs in the Willamette Valley, located on the west side of the Cascade Mountains, mostly in Benton, Clackamas, Lane, Linn, Marion, Polk, and Washington counties. In the Willamette Valley, there are also about 200 to 300 acres of snap beans that are grown for the fresh market.

Washington's snap bean industry, although smaller, is more diverse than Oregon's, with snap beans being grown for processing and fresh market under both conventional and organic production systems. The Washington processed snap bean industry is located in the northwestern part of the state, mostly in Whatcom County. In 2004, Washington produced 8,400 tons of snap beans for processing on 2,000 acres, with a value of $1.6 million. About 30% of the acreage is under organic production. Although the price per ton paid for organic processed snap beans is higher than conventionally grown beans, the yield is generally slightly lower due to increased pest pressures in the field, especially from weed competition. Washington also grows has about 200 acres of snap beans for the fresh market. In the eastern part of the state (mainly the Columbia Basin area), where the weather is warmer and drier and the soils are more alkaline than in the western part, there are about 2,000 acres of lima beans in production. Like snap beans, lima beans are also processed but they are shelled prior to processing. Given that they are grown under different cultural practices and climatic conditions, and have pest management issues different from the processed snap bean industry in western Washington and western Oregon, their pest management issues are not included in this pest management strategic plan. The production of processed snap beans in the eastern part of Washington is currently being tested, but viability of commercial production has not yet been determined.

The deep fertile soils and mild climate in the western part of Oregon and Washington are ideal for growing snap beans. Soils that have good internal drainage and a pH that is neutral or slightly acidic are ideal. Lime is incorporated if the soil pH is below 5.8 to 6.0. Fertilizer is usually added to the soil; the need for fertilizer is based on testing the soil for nutrients prior to planting. Beans grow best in non-compacted soils and seed bed preparation (plowing, disking, deep ripping and cultivation) is performed to provide a loose, well-tilled soil but minimized to avoid compaction. A cover crop, generally small grains, planted in the fall can help prevent erosion and provide fertility and organic matter to the soil for the spring planting of beans. Beans are grown in rotation with other crops suitable to the area; good rotation partners include corn, grass grown for seed, wheat, and other grains. Certain crops that may harbor white mold sclerotia, like lettuce, carrots, brassicas, potatoes, and cucurbits, are avoided in rotation. Gray mold sclerotia may be avoided by not planting beans following strawberries.

Beans are planted in the spring as soon as the soil is dry enough to be worked into a smooth seed bed and warm enough to encourage good seed germination. Good germination is obtained at soil temperatures of 60°F to 80°F. Planting at lower temperatures may cause seed to rot from disease organisms in the soil. Depending on

weather conditions, planting dates in Oregon and Washington range from mid-April to early July. Successive planting dates are necessary to provide the processing facilities with a steady supply of beans during their operation.

Beans are planted in rows that are spaced anywhere from 18 to 30 inches, with 30 inches being the most common. The type of equipment available for cultivating, spraying, and harvesting will influence the row spacing. Plant spacing within the plant row is dependent on the row width; the desired number of plants per acre is achieved by altering the row spacing/plant spacing relationship (e.g., closer within-row plant spacing with wider rows; wider within-row plant spacing with narrower rows). Virtually all seed, except that destined for organic production, is treated by the seed supplier with a fungicide and insecticide to help combat diseases such as damping-off (*Pythium, Rhizoctonia*) and insects such as the seed corn maggot. Bean seed is planted with a mechanical planter. Vacuum seeders are fairly new and gaining in popularity; they place the seed in the soil more accurately than the older generation of seeders, with a minimal amount of damage to the seed. Seeding depth ranges from 3/4 to 1-1/2 inches; placement is critical to ensure contact with soil moisture, quick germination, and seedling emergence.

The most common bean cultivars grown are selections from the Oregon State University breeding program. Popular cultivars grown for processing include Blue Lake types, Italian types (flat-podded), and yellow wax. The processor determines the cultivar to be planted, based on need and market trends.

Irrigation is required to establish a bean crop and continues through the growing season until harvest to ensure good plant growth and productivity. The goal is to have the top 12 inches of soil at about 50% available water. Depending on soil type and weather conditions, irrigation may be required twice per week during early crop development and during periods of warm temperature; well drained soils may need more frequent irrigations but less water applied per application. Bloom and pod set are critical times when the plant should not be water-stressed. Irrigation is performed in the early morning whenever possible to allow the plants to dry out during the day, helping to mitigate foliar disease establishment. However, it is not always possible for the grower to manage irrigation timing. Irrigation types include hand-moved or side-rolled sprinklers, center pivots, and linear- and continuous-move big guns.

Depending on the cultivar, weather, and other factors, about 60 to 80 days elapse from seedling emergence to bean harvest. Timing of the bean harvest is based on processor standards and market demands. Snap beans destined for processing are machine harvested using self-propelled harvesting machines that harvest four or more rows at a time. The harvested beans are not stored but are processed as they arrive at the processing plant. Snap bean processing facilities (which also process other vegetables and fruits) are conveniently located near the production areas. In Oregon and Washington, about 80% of the processed snap beans are frozen and about 20% are canned. Frozen beans are packed alone or in a mix with other vegetables.

Approximate Duration of Crop Development Stages for Processed Snap Beans*

Crop Stage	**Duration** (days)
Planting to Seedling Emergence	10 to 14
Emergence to First Bloom	30 to 40
Bloom**	10 to 14
Pod Development to Harvest**	18 to 21

* Dependent on cultivar, location, weather conditions, and day length.

** For any given plant, bloom and pod development stages overlap (i.e. pods from early flowers will be developing as later flowers are just opening).

Integrated Pest Management (IPM) Strategies in Snap Bean Production

Practically all snap bean growers use some IPM practices (which include cultural, biological, and chemical techniques) in their operation to control insects, diseases, and weeds. The ultimate goal of IPM in bean production is to ensure the production of an abundant, high-quality crop in an environmentally and economically sound manner.

Some IPM practices for disease control include use of resistant cultivars (providing the cultivars acceptable in the marketplace), field scouting, equipment sanitation (when practical), plant and row spacing (dependent on available field equipment), and weed control. For insect control, field scouting helps determine presence and level of pest infestation and timing of pest control options. Scouting and cultivation are used in IPM programs for weed control. When using agricultural chemicals, snap bean growers regularly calibrate pesticide application equipment to ensure proper and accurate delivery.

Foundation for the Pest Management Strategic Plan

The remainder of this document is a discussion of the common pests that can cause significant damage and economic losses during the various growth stages of processed snap beans and the field and worker activities that occur during these stages. This document also summarizes current and potential management practices for these pests. Finally, this document lists what the processed snap bean industry of Oregon and Washington believes are the research, regulatory, and educational needs for managing pests that occur in snap bean production.

The use of trade names does not imply endorsement by the workgroup or any of the organizations represented. Trade names are use as an aid in identifying various products and active ingredients.

Preplant and Planting

Beans grow best in soils that are non-compacted, have good internal drainage, and have a pH that is neutral or slightly acidic. Lime is applied and incorporated prior to planting if pH is below 5.8 to 6.0. Beans are often planted in rotation with corn, grass grown for seed, wheat and other small grains. If an early spring planting of beans is desired, the soil can be plowed in the fall and left fallow and rough-plowed through the winter, which allows the soil to dry out more quickly in the spring and facilitates early entry into the field for seed bed preparation. Fall plow/winter fallow is not, however, a widely used practice. More commonly, a cover crop is planted in the fall, which helps to improve soil structure and fertility; it is then plowed under in the spring. A winter cover crop can, however, delay seed bed preparation in the spring, resulting in beans being planted later in the spring and harvested later in the summer. Preplant soil fumigation for insect, disease, and weed pests is not commonly practiced, as it is not economically feasible. Difficult-to-control perennial weeds are controlled with the use of systemic herbicides prior to planting during site preparation. If the soil has crusted over after planting, a light cultivation in the plant row or a light irrigation in the field facilitates seedling emergence.

Field activities that may occur during Preplant and Planting:

Deep ripping of soil in the fall
Planting cover crops in the fall
Removing cover crops (herbicide or tillage) in the spring
Sampling soil for nutrients, pH
Lime application and incorporation
Seed bed preparation (plow, disk, cultivate)
Flaming for weed control (stale seed bed): an organic practice but not very common
Insecticide application
Fungicide application
Herbicide application
Fertilization
Planting with mechanical seeder
Irrigation pipe setting

Insects

Garden Symphylan

(*Scutigerella immaculata*)

Symphylans are slender, white, centipede-like insects, 1/8- to 1/4-inch long, that live in the soil. Their feeding on sprouting seeds can reduce plant stand, and their feeding on roots of both young and older plants can reduce plant vigor and yield.

Chemical control:

Ethoprop (Mocap). Granular formulations of ethoprop are banded in the seed furrow at planting; liquid formulations are applied broadcast and incorporated. Good control is achieved with either formulation.

Cultural control:

There are no known effective cultural controls for this pest.

Biological control:
None known.

Seed Corn Maggot
(*Delia platura*)

The seed corn maggot overwinters as a larva or pupa in the soil. The larvae, which are about 1/4-inch long and white to pale yellow in color, cause direct damage by feeding on seeds and germinating seedlings and cause indirect damage by creating sites for bacterial and fungal rots.

Chemical control:
At this stage of bean production, growers use seed that has been treated with either chlorpyrifos (Lorsban SL), imidacloprid (Gaucho 480), or thiamethoxam (Cruiser), which protects the seed and seedling from seed corn maggot damage. (Chlorpyrifos is the product most commonly used as a seed treatment for this pest.) Diazinon is registered for use as a planter box treatment but is not commonly used as handling the product is tricky and its use is deemed unnecessary because seed that is already treated with chlorpyrifos provides adequate control.
Cultural control:
Incorporation of cover crop two to three weeks prior to planting does not control seed corn maggot but helps reduce populations.

Plant at proper soil moisture and temperature, if possible, to ensure rapid germination to outgrow larval feeding.

Biological control:
None known.

Wireworms
(*Ctenicera* and *Limonius* spp.)

Wireworms are the soil-dwelling larvae of the click beetle. The larvae are hard, segmented, three eights to one half inch long, and dark yellow to brown. Wireworms feed on roots and can cause significant damage to young seedlings. Older plants are rarely affected.

Chemical control:
Ethoprop (Mocap). Granular formulations of ethoprop are banded in the seed furrow at planting; liquid formulations are applied broadcast and incorporated. Good wireworm control is achieved with either formulation.

Cultural control:
None known.

Biological control:
None known.

Critical Needs for Management of Insects in Snap Beans: Preplant and Planting

Research

- Identify chemical, cultural, or biological controls for symphylans and wireworms (an alternative to ethoprop is needed).
- Develop seed corn maggot risk assessment.
- Identify chemical, cultural, or biological controls for the seed corn maggot (an alternative to chlorpyrifos is needed).
- Develop efficacy data for fipronil (seed treatment or in-furrow application) for control of symphylans, wireworms, and seed corn maggot.

Regulatory

- Retain registration of chlorpyrifos until suitable alternatives have been identified.

Education

- None at this time.

Diseases

Halo Blight
(*Pseudomonas syringae* pv. *phaseolicola*)

This bacterial disease is rare but occasionally appears in Oregon and Washington; frequent wet weather favors its development and spread. On leaves, the disease appears first as water-soaked spots followed by brown spots, usually with yellow halos around them. Defoliation can occur if infection is severe. On bean pods, dark, greasy-looking, water-soaked spots appear, often with a bacterial ooze on the surface; later, the spots become dry and brown. Treatment for this disease occurs during planting; seed is routinely treated with streptomycin.

Chemical control:
Growers use seed that has been treated with streptomycin (AgStrep), which is very effective in managing halo blight.

Cultural control:
None known.

Biological control:
None known.

Damping-off and Stem Rot
(*Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp., and possibly other pathogens)

Damping-off and stem rot are serious and common diseases that occur in snap beans. Treatment takes place just prior to or at planting. These soil-borne fungal pathogens can persist indefinitely in soil or plant debris. Seeds may rot prior to germination ("seed decay"), or the seedling may become infected prior to emergence ("pre-emergence

damping-off") or soon after emergence ("post-emergence damping-off"). Damping-off is favored by wet soils. In the latter cases, the stem of the seedling becomes infected and tissues become discolored and soft, resulting in the seedling toppling over after it has emerged from the ground. Stem infections occurring late in the seedling stage may cause a canker or "wire stem" symptom in which the plant doesn't die, but it is stunted, unthrifty, and may produce adventitious roots.

Chemical control:

Seed treatment:

Azoxystrobin (Dynasty, Protégé): Provides good to excellent control.

Bacillus subtilis (Kodiak FL): A biological product that is used as a seed treatment. Effectiveness is variable.

Captan (Captan 400): Provides good to excellent control.

Carboxin (Vitavax-34): Provides fair control.

Fludioxonil (Maxim 4FS): Not used because efficacy is unknown; more testing is needed.

Mefenoxam (Apron XL): Provides good control.

Metalaxyl (Allegiance FL): Provides very good control, especially when disease pressure is high.

Pentachloronitrobenzene (RTU-PCNB): Provides fair control.

Thiram (Thiram 42-S): Provides excellent control.

Soil treatment:

Azoxystrobin (Amistar, Quadris): Can be applied in-furrow at planting but is not widely used; azoxystrobin seed treatment (Dynasty, Protégé) is preferred.

Mefenoxam (Ridomil Gold EC): May be pre-plant incorporated or applied to the soil surface after planting and moved into the seed zone with irrigation/rainfall or light cultivation but is not commonly used; mefenoxam (Apron XL) or metalaxyl (Allegiance FL) seed treatment is preferred.

Cultural control:

Plant residue management: Incorporation of a cover crop two to three weeks prior to planting, which allows adequate plant residue breakdown, does not control this disease but helps reduce its severity.

Crop rotation: Don’t plant beans following a previous legume crop; a monocot crop rotational partner is best for reducing incidence of damping off and stem rot diseases.

If possible, plant when the soil is warm (generally over 55°F) and has adequate moisture, which promotes quick seed germination and plant growth.

Biological control:
See *Bacillus subtilis* (Kodiak FL), listed above in Chemical Control section.

Fusarium Root Rot
(*Fusarium solani* f. sp. *phaseoli*)

This fungal organism can survive in soil for many years and is common in the soils of western Oregon and Washington. It persists on infected bean straw and spreads when the straw is moved. Wind and water can move infested soil and plant debris. Roots may show a red discoloration, later turning brown and decaying. In severe cases, plants are stunted; leaves are yellowish and can drop prematurely. Infections seldom spread into tissues above ground level. The disease is favored by extremes in soil moisture (too dry or too wet) and is less severe when moisture is near field capacity. Anything which impedes root growth such as cold or compacted soils also favors the disease

Chemical control:
Seed Treatment:

Bacillus subtilis (Kodiak FL): A biological product that is used as a seed treatment; efficacy is unknown.

Trichoderma harzianum (T-22 Planter Box): A biological product that can be used as a seed treatment at the time of planting; efficacy is unknown.

Cultural control:
Rotating into grass or small grain crops for three to four years between bean crops reduces incidence of the disease.

When possible, plant into well-drained soil and avoid compacted soils. Avoid planting in areas with a plow pan.

Biological control:
See biological products listed above in Chemical Control section.

White Mold
(*Sclerotinia sclerotiorum*)

White mold is the most serious disease affecting snap beans. The fungus overwinters as sclerotia (small black structures) attached to decomposing pods, stems, and other plant material in the soil. After a conditioning phase the sclerotia germinate, producing ascocarps which release ascospores. Ascospores primarily infect blooms, which lead to pod or stem infections. Sclerotia may live and remain viable for several years. Sometimes, the presence of white mold in a field may occur as fine cottony wisps of fungal mycelium growing on plant debris on moist soil. Infected stems and pods get water-soaked lesions. Crop yields are severely reduced. Fungicide treatments for white mold are

made to the above-ground plant tissues, usually during early-bloom, but certain cultural practices prior to planting can help mitigate the effects of this disease.

Chemical control:
Coniothyrium minitans (Contans WG): A biological product that is applied to the soil prior to planting and parasitizes sclerotia. Not widely used except, possibly, by some organic growers. Does not provide economical control when used alone; use of a protectant fungicide is required.

Pentachloronitrobenzene (PCNB 2-E): Applied in a band over the row at planting or immediately afterwards. Not used due to marginal efficacy and the possibility of delayed seedling emergence.

Cultural control:
Rotating with grains, grass seed, or corn for at least two years helps reduce incidence of the disease.

Although not always economically feasible, increasing plant and row spacing helps mitigate effects of the disease.

Plant cultivars that have a more upright plant structure, as they tend to better escape early season infection. The cultivar, however, needs to be marketable and acceptable to the processor.

Biological control:
See *Coniothyrium minitans* (Contans WG) listed above in Chemical Control section.

Critical Needs for Management of Diseases in Snap Beans: Preplant and Planting

Research

- Develop efficacy data for chemical, cultural, and biological controls for soil borne pathogens.
- Evaluate efficacy of fludioxonil for control of Fusarium root rot.

Regulatory

- Retain the registration of the chemicals currently used for controlling soil borne pathogens.
- Expedite new registrations as effective, new chemistries are identified.

Education

- Educate growers about biology, ecology, and management of seedling diseases.

Weeds

Low weed densities are essential in snap bean production because processors have a very low tolerance for contamination of the bean crop with weed stems and seeds, particularly nightshade berries. Snap beans are machine harvested and weed plant residue can easily be harvested inadvertently with the bean pods. Weeds are controlled with crop rotation,

herbicides (applied preplant incorporated, postplant surface, and/or postemergence), and cultivation. Crop rotation is commonly used to deplete weed seedbanks prior to snap bean planting. Crop rotation also allows herbicide rotations that help with control of perennial weeds such as bindweed or Canada thistle. Beans are typically rotated with monocot crops such as grains and, in particular, grass seed (broadleaf weeds are more easily controlled in these crops prior to planting beans). The use of stale seedbeds for weed management is not common but is sometimes used in organic snap bean production. The seedbed is prepared several weeks prior to planting, which allows weed seed to germinate. Just before or after planting, but before crop emergence, the field is flamed to kill all germinated and exposed weeds. Conventional growers might use paraquat or glyphosate in place of flaming.

Chemical control:

Site preparation:

Paraquat (Gramoxone): Contact, postemergence herbicide used during site preparation or with stale seedbed (prior to crop emergence).

Preplant incorporated:

EPTC (Eptam): Applied preplant and mechanically incorporated to a depth of two to three inches. Good efficacy.

Metolachlor (Dual Magnum): Applied preplant (within 14 days of planting) and mechanically incorporated. Efficacy is generally good but poor on nightshade, fluvellin, common lambsquarters, smartweed, Canada thistle, and quackgrass. Crop rotation restrictions on the Metolachlor label limit the use of this product for some growers.

Pendimethalin (Prowl): Applied preplant and mechanically incorporated. Good efficacy but crop damage is possible under cool, wet conditions. Not commonly used because of plant-back limitations (if bean crop fails and another crop needs to be planted) and other limitations affecting choice of crop rotation partners.

Trifluralin (Treflan): Applied preplant and mechanically incorporated within 24 hours to a depth of two to three inches. Good control but use is limited because of crop rotation issues with grass seed or grains.

Preemergence (of crop and weed):

Clomazone (Command): Applied prior to planting or after planting but prior to crop emergence. Long plant-back restrictions limit rotational crop partners. Not widely used because of off-target drift concerns.

DCPA (Dacthal): Applied immediately after planting and activated with irrigation or rain. Not used because efficacy is poor and very erratic (depending on soil moisture and temperature) in western Oregon and Washington.

Halosulfuron (Sandea): Works well on some broadleaves but not effective in controlling nightshade. Not widely used because it is expensive and doesn't fit well into common crop rotations due to its long crop rotation restrictions.

Lactofen (Cobra): Applied within 48 hours after planting followed by rain or irrigation before the germinating beans crack the soil and emerge. Oregon registration only. Lactofen is particularly effective in controlling nightshade, one of the more problematic weeds found in bean fields.

Metolachlor (Dual Magnum): Applied after planting and activated with irrigation or rain. Good efficacy except on weeds noted above under Preplant Incorporated. Dual Magnum is the most widely used preemergence herbicide in snap bean production.

Postemergence:

Pelagonic acid (Scythe): Non-selective, non-systemic, postemergent herbicide applied to actively growing weeds but prior to crop emergence. Not widely used but may be used by some organic growers.

Glyphosate (Roundup): Non-selective, systemic, postemergent herbicide applied to actively growing weeds but prior to crop emergence.

Cultural control:

A cover crop planted in the fall helps suppress winter annual weeds. Cover crop residue left on the soil surface in no-till or strip till situations can suppress certain spring and summer annual broadleaf weeds.

A rotation with monocots, especially in the year prior to planting, is essential for good weed management during the bean crop.

Equipment sanitation can help prevent introduction of weeds and weed seed into the bean field (especially weeds like wild-proso millet, puncturevine, nutsedge, and mustards).

Biological control:

None known.

Critical Needs for Management of Weeds in Snap Beans: Preplant and Planting

Research

- Investigate biocontrol for difficult-to-control weeds.
- Obtain efficacy and crop safety data for newer herbicide chemistries.
- Obtain crop safety data for dimethenamid-P (Outlook) in Oregon and Washington.
- Determine efficacy and economics of non-chemical weed control practices, such as flaming, mechanical, robotic, and GPS weed mapping.
- Determine level of weed control achieved with seed predation by soil-dwelling insects.
- Determine level of weed control achieved with seed bank management and tillage.
- Investigate various cover crops for their effect on suppressing weeds and reducing weed seed.
- Determine the efficacy and suitability of biofumigation and chemigation.

Regulatory

- Expedite registration of dimethenamid-P (Outlook) once crop safety is verified.

Education

- Educate growers about weed management with crop rotation and cultural controls.
- Educate growers about the different management strategies that can be used in bean production and remind them of rotating herbicides to avoid resistance and weed species shifts.

Emergence to Bloom

Under ideal soil moisture and temperature conditions, bean seed should germinate and emerge within 10 to 14 days. Prompt emergence is desirable, as any delay in emergence exposes seedlings to increased rates of herbicide, as well as seed and seedling pathogens. The seedling emerges as a cotyledon and develops trifoiate leaves within a few days. Depending on the weather, it takes about 30 to 40 days to go from seedling emergence to bloom. (Emergence to first fully expanded trifoliate leaf takes about 7 to 10 days; first trifoliate leaf to second trifoliate leaf takes about 7 days. The plant continues to grow vegetatively for another 15 to 25 days.) During the time of emergence, seedling development, and vegetative growth, irrigation is applied to keep the top 12 inches of soil at or near 50% available water. Fields are checked for insects, diseases, weeds, and slugs; if pest populations warrant it, control measures are applied.

Field activities that may occur during Emergence to Bloom:

Check fields for insects, diseases, weeds, and slugs
Fertilization
Herbicide application
Fungicide application
Insecticide application
Molluskicide application
Irrigation
Cultivation between rows for weed control
Hand hoe or hand pull weeds (not common)

Vertebrates

Feeding by geese on newly emerged seedlings can reduce the plant stand, often creating the need to replant areas of the field. There are no chemical controls available for repelling geese. Scare balloons are sometimes used keep geese out of the bean field but their effectiveness is erratic and marginal, at best. Feeding by deer can also severely reduce plant stand. Hunting permits are available to growers for control of deer in bean fields.

Critical Needs for Management of Vertebrates in Snap Beans: Emergence to Bloom

Research

- Identify effective control options for geese management.

Regulatory

- Retain use of hunting permits for deer control.
- Allow hunting permits for geese management.

Education

- Inform growers of options for vertebrate management.

Insects, Mites, Mollusks

Aphids

Green peach aphid (*Myzus persicae*)

Potato aphid (*Macrosiphum euphorbiae*)
Bean aphid (*Aphis fabae*)
Pea aphid (*Acyrthosiphon pisum*)

Aphids may appear any time during growth of the bean plant but treatment is very rare, as the bean plant can tolerate aphid feeding. Aphids prefer to feed on green, succulent plant material; they can be found on leaves, stems, and on the growing tips of the plant. Their feeding can cause leave to curl or wilt, and plants to lose vigor and be stunted. Large amounts of honeydew secretions promote development of sooty mold on foliage and fruit.

Chemical control:
Note: Treatment for aphids is not common. Products like bifenthrin (Capture 2EC), esfenvalerate (Asana), or lambda-cyhalothrin (Warrior T) that are used to control the cucumber beetle will also control aphids.

Cultural control:
Avoid overfertilization.

Biological control:
None known.

Armyworms and Cutworms
Beet armyworm (*Spodoptera exigua*)
Bertha armyworm (*Mamestra configurata*)
Yellowstriped armyworm (*Spodoptera praefica*)
Black cutworm (*Agrotis ipsilon*)
Variegated cutworm (*Peridroma saucia*)

Armyworms and cutworms can attack snap beans during the early stages of plant growth but their occurrence is very rare. These pests are the larval stage of moths (caterpillars); the ones that are found in bean fields vary in color and size. Feeding by young armyworm larvae can skeletonize bean leaves and, as larvae grow, they consume entire leaves. Cutworms do most of their feeding near the soil line, often cutting off seedlings at ground level. The variegated cutworm also climbs up into plants to feed.

Chemical control:
Note: Although treatment for armyworms and cutworms is not common, the following insecticides can be used if treatment is deemed necessary.

Bacillus thuringiensis (various brands): A biological product that controls armyworms only. It is most effective on small larvae.

Carbaryl (Sevin): Good control. Toxic to bees.

Esfenvalerate (Asana XL): Good control.

Lambda-cyhalothrin (Warrior T): Good control.

Spinosad (Success): Controls armyworm only. Spinosad takes several days to achieve its full effect.

Cultural control:
None known.

Biological control:
See *Bacillus thuringiensis* (Bt) listed above in the Chemical Control section.

Cucumber Beetle
Western spotted cucumber beetle (*Diabrotica undecimpunctata*)
Western striped cucumber beetle (*Acalymma trivittatum*)

The adult cucumber beetle causes most damage by feeding on developing bean pods (see following crop stage, Bloom to Harvest), which is the most common time for treatment, but they can also cause damage by feeding on leaves. If adult populations are large and feeding by adult beetles is severe, insecticides are sometimes applied to control them during the early stages of plant growth. Sticky traps and sweep nets are used to monitor populations. Cucumber beetle larvae feed on roots and can bore into the stem of the bean plant.

Chemical control:
Bifenthrin (Capture 2EC): Restricted use. Toxic to fish. Good control.

Carbaryl (Sevin): Provides excellent control. Toxic to bees.

Esfenvalerate (Asana XL): Provides excellent control.

Lambda-cyhalothrin (Warrior T): Provides excellent control but not widely used due to cost (too expensive).

Malathion: Control is marginal.

Pyrethrin and rotenone (Pyrellin): Multiple applications at 7-day or shorter intervals are required. Does not provide satisfactory control. Approved for organic production.

Cultural control:
None known.

Biological control:
None known.

Slugs
Grey garden slug (*Deroceras reticulatum*)
Large spotted garden slug (*Limax maximus*)
Reticulated slug (*Prophysaon andersoni*)

Slugs are a relative to snails but have no shell. They are active above ground primarily at night but also at any time during mild, wet periods. Slugs feed on foliage and can cause severe damage to newly emerged seedlings. Growers monitor slug populations with bait stations or by noting slime trail evidence.

Chemical control:
Metaldehyde baits provide good control but repeat applications are often necessary.

Cultural control:
Good weed control in the field and at field borders eliminates slug habitat. Rotational crop partners are considered; if possible, avoid planting beans following a perennial legume crop or certain grass crops.

Biological control:
None known.

Spider Mites
Twospotted spider mite (*Tetranychus urticae*)
Strawberry spider mite (*Tetranychus turkestani*)
Pacific spider mite (*Tetranychus pacificus*)

Infestations include a mixture of spider mite species can that multiply rapidly under warm, dry conditions. Spider mite feeding causes stippling on the upper leaf surface and can cause plant wilting, leaf deformity, and tissue death.

Chemical control:
Bifenthrin (Capture 2EC): Restricted use. Toxic to fish. Not commonly used for mite control.

Dicofol (Kelthane): Good control.

Insecticidal soap (M-Pede): Good option for organic growers.

Cultural control:
Avoid overfertilization.

Biological control:
Predatory mites are available commercially but they are neither practical nor economical.

Critical Needs for Management of Insects in Snap Beans: Emergence to Bloom

Research

- Identify chemical, cultural, or biological control options for slug management.
- Develop risk assessment for slugs.

Regulatory

- None identified.

Education

- Educate growers about scouting and monitoring for slugs.

Diseases

Halo Blight
(*Pseudomonos syringae* pv. *phaseolicola*)

As mentioned in the Preplant and Planting section, this disease is not common and is usually controlled with a seed treatment of streptomycin. If, however, symptoms appear during plant growth, and there are low levels of the pathogen in the field, copper (Champ, Kocide) is sometimes applied, which helps slow spread of the disease.

Gray Mold
(*Botrytis cinerea*)

Gray mold may occasionally appear during this stage but treatment is generally not applied at this time (treatment occurs during bloom). However, with the pending loss of vinclozolin (Ronilan), gray mold may begin to occur more frequently between emergence and bloom. Avoiding overfertilization, well timed irrigation, and increasing plant and row spacing all can help reduce incidence of the disease.

Critical Needs for Management of Diseases in Snap Beans: Emergence to Bloom

Research

- Obtain efficacy data for boscalid (Endura) and other fungicides for control of Botrytis gray mold, given the pending cancellation of vinclozolin (Ronilan).
- Evaluate tank mixes of fungicides for Botrytis control.
- Develop scouting techniques for monitoring occurrence of Botrytis.
- Develop weather-based forecast models for predicting occurrence and outbreak of Botrytis.
- Develop efficacy data for fluazinam (Omega) in beans for Botrytis control.

Regulatory

- Extend vinclozolin (Ronilan) registration while alternatives are evaluated.
- Expedite the registration of Ronilan alternatives, especially cost-effective ones.

Education

- Explain to growers Botrytis management strategy once use of Ronilan is no longer allowed.
- Educate growers about systemic and contact fungicides and the importance of application timing.

- Continue to educate growers about fungicide chemical classes and resistance management.

Weeds

Most weed control occurs prior to or after planting but weed control is sometimes necessary after the bean seedling has emerged and as the plant grows. Postemergence herbicides are applied to control escaped weeds. If weeds persist and weather allows, timely cultivation before row closure removes weeds that have escaped, mitigates soil crusting, and improves bean growth in some situations.

Chemical control:

Bentazon (Basagran): Postemergence herbicide for broadleaf weeds. Applied only after the first trifoliate bean leaf is fully expanded. This product is widely used and, generally, very effective but does not control nightshade or pigweed (timing is critical for pigweed control; no control if pigweed is too large).

Glyphosate (Roundup): Good control of broadleaf and grass weeds. Application is to the row middles with a hooded sprayer or, less commonly, wick wiper.

Imazamox (Raptor): Postemergence herbicide for broadleaf weeds and some grass weeds. Applied between the first and second trifoliate leaf stage of the bean plant. Use is allowed under a supplemental label that includes Oregon and Washington and, for increased crop safety, only as a tank mix with bentazon. Useful primarily for nightshade (timing of application is critical to achieve effective nightshade control) and pigweed control.

Pelargonic acid (Scythe): Non-selective, contact, postemergence herbicide. Not commonly used at this stage due to concerns about crop safety (contact with the bean plant must be avoided).

Quizalofop P-ethyl (Assure II): Postemergence grass herbicide. Effective but not widely used (grass control is not usually needed at this crop stage).

Sethoxydim (Poast): Postemergence grass herbicide. Effective but not widely used (grass control is usually not needed at this crop stage).

Cultural control:

Cultivation between rows will help control annual weeds.

Hand hoeing is occasionally employed to control seed bank (hoeing is done before a weed has a chance to disperse its seeds). This is not widely used because it is quite costly.

Equipment sanitation can help prevent introduction of weeds and weed seed into the bean field.

Biological control:

None known.

Critical Needs for Management of Weeds in Snap Beans: Emergence to Bloom

Research

- Determine efficacy and crop safety data for newer herbicide chemistries.
- Determine and understand weed species shifts when certain herbicides and cultural weed control practices are used.

Regulatory

- Expedite the registration of fomesafen (Reflex), an herbicide with postemergence and some preemergence activity, which will be helpful in controlling nutsedge, broadleaf, and grass weeds. Environmental risk assessments for western states were not completed when Reflex was registered several years ago for use east of the Rocky Mountains. However, Syngenta is now able to actively pursue a federal registration that will include Oregon and Washington.

Education

- Educate growers about scouting for weeds to identify shifts in weed species.

Bloom through Harvest

An individual bean flower may be open for just two or three days but, depending on the weather, the bloom period in a given bean field may last 10 to 14 days. Once the flower is pollinated (bean flowers are self-pollinating), it sceneses and a bean pod begins to develop. Flowers and young pods are present at the same time: pods from early flowers will be developing as later flowers are opening. It takes about 18 to 21 days for pods to reach harvest maturity. Snap beans destined for processing are machine harvested with self-propelled harvesting machines that harvest four or more rows at a time. Timing of the harvest is dependent on processor standard and market demands. Processed beans are not stored but are processed as they arrive at the processing plant. In Oregon and Washington, about 80% of the snap beans grown for processing are frozen, and about 20% are canned.

Bloom and pod development are critical times for pest management, as diseases and insects at this time can affect bean quality and yield. White mold is the most serious pest affecting snap beans because it can substantially reduce yields and, also, reduce quality; almost all other pest management and production management decisions are based on how they relate to mold management. Vinclozolin (Ronilan) is the fungicide most widely used for white mold control, as it is inexpensive and very effective. It is generally applied at about 10 to 20% bloom but time of application varies with each individual grower. A second application of vinclozolin is sometimes made seven to ten days later if a visual inspection of the plants indicates presence of white mold. Vinclozolin applications for white mold will also control gray mold (Botrytis) at the same time. One of the biggest concerns for snap bean growers is the pending cancellation of Ronilan, which is to take effect after the 2005 field season. Unlike currently registerered fungicides, and those registrations that are pending, vinclozolin has curative properties and can elimnate white mold once it is established on the bean pods. The need for a vinclozolin replacement is critical, as is testing and redesigning a fungicide spray program once vinclozolin use is cancelled.

Field activities that may occur during Bloom through Harvest:

Check for insects, diseases, weeds, and slugs
Fertilization (foliar for micronutrients)
Herbicide (postemergence) application (not common)
Fungicide application
Insecticide application
Molluskicide application
Irrigation
Hand hoe or hand pull weeds (not common)
Machine harvest

Insects

Aphids, Armyworms, Cutworms

As mentioned earlier (see Emergence to Bloom section) these pests are not common. They may appear between bloom and harvest, but treatment is not commonly practiced even when they do occur.

Cucumber Beetle

Western spotted cucumber beetle (*Diabrotica undecimpunctata*)
Western striped cucumber beetle (*Acalymma trivittatum*)

The adult cucumber beetle is the most serious insect pest of snap beans. They migrate in from surrounding areas. They cause damage by feeding on developing bean pods, leaving feeding holes and causing pod deformity. They also like to feed on the petioles of leaves and developing blossoms. Sweep nets are commonly used to monitor populations (sticky traps can also be used but are not as common). Regardless of monitoring method, visual inspection of the crop is necessary.

Chemical control:

Bifenthrin (Capture 2EC): PHI 3 days. Restricted use. Toxic to fish. Efficacy is good but it is not widely used due to limitations and restrictions.

Carbaryl (Sevin): PHI 3 days. Efficacy is excellent but cannot be used when blooms are present (bee toxicity). After esfenvalerate (Asana), carbaryl is the most commonly used insecticide for control of the cucumber beetle.

Diatomaceous earth and pyrethrin (Diatect): PHI 0 days. EC formulations can be phytotoxic. Used only by organic growers, if at all.

Endosulfan: PHI 3 days. Currently under review at EPA; not commonly used, as this chemistry is not favored by end-users of processed snap beans.

Esfenvalerate (Asana XL): PHI 3 days. The product of choice and most commonly used active ingredient for cucumber beetle control; it is inexpensive, very effective, easy to handle, and also controls other insect pests that might be present.

Lambda-cyhalothrin (Warrior T): PHI 7 days. Not used because it is not economically feasible (too expensive).

Malathion: PHI 1 day. Not commonly used as it provides only fair control.

Methomyl (Lannate LV): PHI 1 days. Not used due to bird toxicity issues.

Pyrethrin and rotenone (Pyrellin): PHI 0 days. Multiple applications at 7-day or shorter intervals are required. Does not provide satisfactory control. Approved for organic production.

Cultural control:

Trap crops may work but are still experimental and unproven.

Biological control:

Tachinid fly is naturally occurring but does not provide enough control to be a stand-alone option.

Lygus Bugs
(*Lygus spp.*)

Lygus bug feeding can cause damage to bean blossoms and pods. This pest is more commonly found in Washington than Oregon. Yield losses due to lygus bug feeding have not been documented and are not known. Treatment specifically for lygus bug is rare; control of the lygus bug is achieved when insecticides are applied for control of the cucumber beetle.

Spider Mites
Twospotted spider mite (*Tetranychus urticae*)
Strawberry spider mite (*Tetranychus turkestani*)
Pacific spider mite (*Tetranychus pacificus*)

Spider mite feeding causes stippling on the upper leaf surface and can cause plant wilting, leaf deformity and tissue death which affects pod quality and yield.

Chemical control:
Bifenthrin (Capture 2EC): Restricted use. Toxic to fish. PHI 3 days. Not commonly used for mite control.

Dicofol (Kelthane): Good control but 21 day PHI limits usefulness prior to harvest.

Insecticidal soap (M-Pede): Marginal efficacy but good option for organic growers. PHI 0 days.

Cultural control:
Avoid overfertilization.

Biological control:
Predatory mites are available commercially but they are neither practical nor economical.

Critical Needs for Management of Insects in Snap Beans: Bloom through Harvest

Research

- Develop data for and determine efficacy of attract-and-kill technology for control of the cucumber beetle.
- Determine impact of lygus bug feeding on bean yields and develop an economic threshold, if necessary.
- Screen reduced-risk, target-specific chemical alternatives to broad-spectrum insecticides for cucumber beetle control.

Regulatory

- None at this time.

Education

- None at this time.

Diseases

Gray Mold
(*Botrytis cinerea*)

Bloom is the critical time to apply fungicides for gray mold control. Left unchecked, gray mold can cause significant economic losses due to reduced pod quality and possible load rejection at the processing plant. The current prevailing fungicide program for gray mold control relies on the application of vinclozolin (Ronilan) application for white mold control, which occurs most commonly at 10 to 20% bloom. A second fungicide application is sometimes needed seven to 10 days after initial application if white mold or gray mold symptoms are discovered. Warm, wet weather is conducive to the development and spread of both diseases.

Chemical control:
Boscalid (Endura): PHI 7 days. Not widely used because of cost.

Chlorothalonil (Bravo Ultrex, Terranil, Countdown): PHI 7 days. Not very effective for Botrytis control but occasionally included in a spray program for resistance management.

Iprodione (Rovral 4F): Last application is not allowed past peak bloom. Effectiveness is unknown at 18 to 30 inch row spacing; fair control at 30 to 36 inch row spacing.

Thiophanate-methyl (Topsin M): Poor efficacy when used alone, due to resistant populations of *Botrytis cinerea*. University researchers are currently evaluating a tank mixture of thiophanate-methyl + a reduced rate of boscalid (to reduce costs), hoping to control gray mold with the boscalid component of the mixture and also achieve control of white mold with the two chemistries.

Vinclozolin (Ronilan EG): PHI 10 days. Ronilan is the most widely used fungicide for Botrytis control because it is very effective and inexpensive. Use is to be cancelled after the 2005 field season.

Cultural control:
Proper amount and timing of irrigation, when possible, helps reduce likelihood of the disease.

Biological control:
None known.

Rust
(*Uromyces appendiculatus*)

Rust can form blisters on leaves and petioles, causing leaf death and a reduced crop. However, this disease rarely occurs in the snap bean growing regions of Oregon and Washington and treatment is not common. If treatment is deemed necessary, fungicides are applied when the disease first appears. Choices of fungicides for rust control include azoxystrobin (Amistar, Quadris), boscalid (Endura), chlorothalonil (Bravo Ultrex),

myclobutanil (Rally 40W), or pyraclostrobin (Headline). Reducing moisture in the field by eliminating weeds helps reduce the likelihood of disease development.

White Mold
(*Sclerotinia sclerotiorum*)

White mold is one of the most serious diseases to affect snap beans; crop yields are severely reduced when infection is high. When soil conditions are favorable, sclerotia (small black structures) in the soil develop apothecia that produce millions of fungal spores, which are spread by wind and infect senescent tissue such as blossoms and leaves. Spread of the disease occurs when infected plant tissue comes in contact with developing bean pods. Fungicide treatments for white mold begin at early bloom but, with vinclozolin (Ronilan) being the most widely-used product, application usually occurs at about 10 to 20% bloom. If visual inspections indicate presence of white mold symptoms, a second application of vinclozolin is made about seven days later. With the pending cancellation of vinclozolin after the 2005 field season, the timing of fungicide applications for white mold control may change.

Chemical control:
Bacillus pumilis (Sonata): A biological product. Efficacy is unknown in the Pacific Northwest.

Bacillus subtilis (Serenade MAX): A biological product that is applied to the foliage; provides only fair control of white mold. Not used, as it requires tank mixing with protectant fungicides.

Boscalid (Endura): PHI 7 days. A protective fungicide applied at the beginning of flowering and repeated in 7 to 10 days. Very costly. Further evaluations of efficacy and application timing are required; some studies in Oregon have shown boscalid to not be as effective as vinclozolin (Ronilan).

Coniothyrium minitans (Contans WG): A biological product that may contribute to control when used in conjunction with chemical fungicides; it does not provide adequate control when used alone.

Dichloran (Botran 75-W): Poor efficacy.

Iprodione (Rovral 4F): Last application is not allowed past peak bloom. Provides only fair control of white mold.

Thiophanate-methyl (Topsin-M 70 W): PHI 14 days. Not much experience with this product but data suggests good efficacy. Further testing is needed, especially at 18 to 30 inch row spacing. The long PHI permits just one early bloom spray, leaving unprotected blooms that open after the thiophanate-methyl application, requiring a second application of a fungicide with a shorter PHI such as boscalid (Endura) or vinclozolin (Ronilan).

Vinclozolin (Ronilan DF): PHI 7 days. Very effective and the most widely used fungicide for white mold control because it is inexpensive, has excellent efficacy, and has curative properties. Use is to be cancelled after the 2005 field season.

Cultural control:
None known.

Biological control:
None known.

Critical Needs for Management of Diseases in Snap Beans: Bloom through Harvest

Research

- Identify an effective and inexpensive replacement for vinclozolin (Ronilan).
- Determine efficacy of thiophanate-methyl (Topsin M) for control of white mold in the Pacific Northwest.
- Determine efficacy of all fungicides currently registered for white mold control.
- Develop effective field scouting techniques for monitoring white mold occurrence.
- Develop and test cultivars for management of Botrytis gray mold and white mold.
- Determine timing of fungicides other than vinclozolin (Ronilan) for optimum Botrytis gray mold and white mold control.
- Develop weather-based forecast models for predicting occurrence and outbreak of Botrytis.

Regulatory

- Retain vinclozolin (Ronilan) registration until an effective replacement can be identified and registered.
- Expedite registration of new fungicides, once identified.

Education

- Continue to educate growers about fungicide chemical classes and resistance management.
- Educate growers about the risks of failing to control white mold and gray mold.

Weeds

Weed management opportunities between bloom and harvest are limited, as intervention is difficult after the canopy of the bean plants closes between the rows. Hand pulling or hoeing can be justified economically if other strategies up to this point have failed (weed density is high late in the season) and the threat of weed contamination in the harvested bean crop could result in significant dockage or rejection of the bean loads at the processing plant.

Chemical control:
Grass weeds are usually not a problem at this time but if they are, postemergence grass herbicides such as Quizalofop P-Ethyl (Assure II) or Sethoxydim (Poast) can be used. Both herbicides control actively growing annual and perennial grasses and both have a 15-day PHI. Roundup can be used with a hooded sprayer or wick wiper but is not common at this crop stage because of the closed plant canopy and risk of crop damage.

Cultural control:
Hand hoeing or pulling to prevent weeds from dispersing seeds.

Biological control:
None known.

Critical Needs for Management of Weeds in Snap Beans: Bloom through Harvest

Research

- None at this time.

Regulatory

- None at this time.

Education

- None at this time.

References

1. Fertilizer Guide, Bush Beans - West of the Cascades. Oregon State University. Publication No. FG-28, http://eesc.orst.edu/agcomwebfile/edmat/html/FG/FG28-E/FG28-E.html, web site verified on May 10, 2005.

2. Integrated Pest Management: Managing Pathogens with Information, Crop Rotation. Washington State University. http://mtvernon.wsu.edu/plant_pathology/ipm.htm, web site verified on May 10, 2005.

3. Interregional Research Project #4. http://ir4.rutgers.edu/Food_Use.cfm, web site verified on May 10, 2005.

4. Pacific Northwest Insect Management Handbook. 2004. Oregon State University, Washington State University, and the University of Idaho.

5. Pacific Northwest Weed Management Handbook. 2004. Oregon State University, Washington State University, and the University of Idaho.

6. Pacific Northwest Plant Disease Management Handbook. 2004. Oregon State University, Washington State University, and the University of Idaho.

7. Snap Bean Production Guide for the Pacific Northwest. Revised August 6, 2004. Oregon State University. http://oregonstate.edu/Dept/NWREC/snapbean.html, web site verified on May 10, 2005

8. Vegetable Summary, 2004. National Agricultural Statistics Service and U. S. Department of Agriculture. http://usda.mannlib.cornell.edu/reports/nassr/fruit/pvg-bban/vgan0105.pdf, web site verified on May 10, 2005.

Activity Table for Oregon and Washington Processed Snap Beans

Cultural Activities												
Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cover crop establishment									XXXX	XXXX		
Cover crop removal			XX	XXXX	XXXX							
Deep ripping of soil									XX	XXXX		
Fertilization				XX	XXXX	XXXX	XXXX					
Fertilization (foliar micronutrients)					X	XXXX	XXXX	XXXX				
Irrigation				X	XXXX	XXXX	XXXX	XXXX	XXXX			
Irrigation installation				XX	XXXX							
Harvest						XX	XXXX	XXXX	XX			
Lime application and incorporation									XX	XXXX		
Planting				XX	XXXX	XXXX	X					
Seed bed preparation (till, disk, cultivate)			XXXX	XXXX	XXXX							
Soil testing for nutrients and pH			XXXX	XXXX								

Pest Management Activities												
Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cultivation between rows for weed control				X	XXXX	XXXX	XX					
Flaming for weeds (stale seed bed)				XX	XXXX	XX						
Fungicide application (excluding seed trts)						XXXX	XXXX	XXXX	X			
Hand hoe or hand pull weeds						XXXX	XXXX	XXXX				
Herbicide application				XX	XXXX	XXXX	XXXX	XX				
Insecticide application				XX	XXXX	XXXX	XXXX	XXXX	XXXX			
Molluskicide application				XX	XXXX	XX						
Scouting for diseases, insects, and weeds					XXXX	XXXX	XXXX	XXXX	XXXX			

Seasonal Pest Occurrence* for Oregon and Washington Processed Snap Beans

(*Time when the pest causes problems or is targeted for control)

Insects	J	F	M	A	M	J	J	A	S	O	N	D
Aphids					XX	XXXX	XXXX	XXXX	XX			
Armyworms and cutworms				XX	XXXX	XXXX	XXXX					
Cucumber beetle					XXXX	XXXX	XXXX	XXXX	XXXX			
Lygus bug						XXXX	XXXX	XXXX				
Seed corn maggot				XXXX	XXXX	XXXX	XX					
Spider mites						XXXX	XXXX	XXXX	XXXX			
Symphylans				XXXX	XXXX	XXXX	XX					
Wireworms				XXXX	XXXX	XXXX	XX					
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Damping off and stem rot				XX	XXXX	XXXX	XXXX					
Fusarium root rot				XX	XXXX	XXXX	XXXX					
Gray mold						XXXX	XXXX	XXXX	XXXX			
Halo blight				XX	XXXX	XXXX	XXXX	XXXX				
Rust						XXXX	XXXX	XXXX				
White mold						XXXX	XXXX	XXXX	XXXX			
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Grasses:												
Annual ryegrass			XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Barnyardgrass					XX	XXXX	XXXX	XXXX	XXXX			
Crabgrass					XXXX	XXXX	XXXX	XXXX	XXXX			
Wild-proso millet				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Quackgrass (perennial)					XXXX	XXXX	XXXX	XXXX	XXXX			
Annual Broadleaves:												
Fluvellin				XXXX	XX							
Groundsel				XXXX	XXXX	XXXX	XX					
Knotweed					XX	XXXX	XXXX	XX				
Lambsquarters, common				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Mayweed/Dogfennel				XXXX	XXXX	XXXX						
Mustards				XXXX	XXXX	XX						
Nightshade, black				XXXX	XXXX	XXXX	XXXX	XX				
Nightshade, hairy					XX	XXXX	XXXX	XXXX	XXXX			
Pigweeds				XX	XXXX	XXXX	XXXX	XXXX				
Prickly lettuce				XXXX								
Puncturevine						XX	XXXX	XXXX	XXXX			
Purslane						XX	XXXX	XXXX	XX			
Smartweed/Lady's thumb				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Sow thistle				XXXX								
Wild buckwheat				XXXX	XXXX	XXXX						
Perennial Broadleaves:												
Canada thistle				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Field bindweed				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Nutsedge				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			

Efficacy Ratings for INSECT and MITE Management Tools in Processed Snap Beans

Rating scale: **E** = excellent (90-100% control); **G** = good (80-90% control); **F** = fair (70-80% control); **P** = poor (<70% control); **?** = efficacy unknown, more research needed; ***** = used but not a standalone management tool; **-** = not used for this pest.

Note: [a] following a management tool indicates a seed treatment

MANAGEMENT TOOLS	Aphid	Armyworm and Cutworm	Cucumber beetle	Seed corn maggot	Spider mite	Symphylan	Wireworm	COMMENTS
Registered Chemistries								
Bifenthrin (Capture)	G	-	G	-	G	-	-	
Carbaryl (Sevin)	-	G	E	-	-	-	-	
Chlorpyrifos (Lorsban SL) [a]	-	-	-	G	-	-	-	Seed treatment
Diazinon [a]	-	-	-	F	-	-	-	Planter box seed treatment
Diatomaceous earth and pyrethrin (Diatect)	-	-	?	-	-	-	-	Organic approved; can be phytotoxic
Dicofol (Kelthane)	-	-	-	-	G	-	-	
Endosulfan (Thiodan)	F-G	F	G	-	-	-	-	
Esfenvalerate (Asana)	G	G	E	-	-	-	-	
Ethoprop (Mocap)	-	-	-	G	-	G	G	Used at planting
Imidacloprid (Gaucho 480) [a]	G	-	-	G	-	-	F	Seed treatment
Lambda-cyhalothrin (Warrior T)	G	G	E	-	-	-	-	Expensive
Malathion	-	-	P-F	-	-	-	-	
Methomyl (Lannate LV)	G	F-G	G	-	-	-	-	Bird toxicity
Pyrethrin + rotenone (Pyrellin)	-	-	P	-	-	-	-	Organic approved
Soaps	F	-	-	-	F	-	-	Organic approved
Spinosad (Success)	F	F	-	-	-	-	-	Armyworm only
Thiamethoxam (Cruiser) [a]	G	-	-	G	-	-	?	Seed treatment
Unregistered / New Chemistry								
Acetamiprid (Assail)	G	-	?	-	-	-	-	
Buprofezin (Applaud)	?	-	?	-	-	-	-	
Fipronil (Regent)	-	-	-	?	-	?	?	Seed treatment and/or in-furrow at planting
Indoxacarb (Avaunt)	-	G	?	-	-	-	-	
Methoxyfenozide (Intrepid)	-	G	-	-	-	-	-	
Novaluron (Diamond)	-	G	?	-	-	-	-	
Pyriproxyfen (Esteem)	?	?	?	-	-	-	-	
Thiamethoxam (Actara, Platinum)	G	-	?	-	-	-	-	
Biological								
Bacillus thuringiensis (Bt)	-	G	-	-	-	-	-	Armyworms only; effective on small ones
Cultural / Non-Chemical								
Crop rotation	-	-	-	-	-	*	-	
Nutrition management (no overfertilization)	*	-	-	-	*	-	-	
Tillage	-	*	-	*	-	*	-	
Trap crops	?	-	?	-	-	-	-	

Efficacy Ratings for DISEASE Management Tools in Processed Snap Beans

Rating scale: **E** = excellent (90-100% control); **G** = good (80-90% control); **F** = fair (70-80% control); **P** = poor (<70% control); **?** = efficacy unknown, more research needed; **-** = not used for this pest; ***** = used but not a standalone management tool.

Note: [a] following a management tool indicates a seed treatment

MANAGEMENT TOOLS	Damping-off & Stem rot	Fusarium root rot	Gray mold	Halo blight	Rust	White mold	COMMENTS
Registered Chemistries							
Azoxystrobin (Amistar, Quadris)	?	-	-	-	G	-	
Azoxystrobin (Dynasty, Protégé) [a]	G-E	-	-	-	-	-	Seed treatment
Boscalid (Endura)	-	-	G	-	G	F	Expensive
Captan (Captan 400) [a]	G-E	-	-	-	-	-	Seed treatment
Carboxin (Vitavax-34) [a]	F	-	-	-	-	-	Seed treatment
Chlorothalonil (Bravo, Terranil, Countdown)	-	-	P	-	G	-	
Copper (Champ, Kocide)	-	-	-	P	-	-	Poor control but slows spread of the disease
Dichloran (Botran 75-W)	-	-	-	-	-	P	
Fludioxonil (Maxim FS) [a]	?	?	-	-	-	-	Seed treatment
Iprodione (Rovral)	-	-	F	-	-	F	Gray mold control is fair at 30-36" row spacing
Mefenoxam (Apron XL) [a]	G	-	-	-	-	-	Seed treatment
Mefenoxam (Ridomil Gold)	G	-	-	-	-	-	
Metalaxyl (Allegiance FL) [a]	G-E	-	-	-	-	-	Seed treatment
Myclobutanil (Rally)	-	-	-	-	G	-	
Pentachloronitrobenzene (PCNB 2-E)	-	-	-	-	-	P	
Pentachloronitrobenzene (RTU-PCNB) [a]	F	-	-	-	-	-	Seed treatment
Pyraclostrobin (Headline)	-	-	-	-	G	-	Supplemental label
Streptomycin (AgStrep) [a]	-	-	-	E	-	-	Seed treatment
Thiophanate-methyl (Topsin M)	-	-	P	-	-	G	White mold control is good at 30-36" row spacing
Thiram (Thiram 42-S) [a]	E	-	-	-	-	-	Seed treatment
Vinclozolin (Ronilan)	-	-	E	-	-	E	Scheduled for cancellation
Unregistered / New Chemistries							
Cyprodinil + fludioxonil (Switch)	-	-	G	-	-	P	
Fluazinam (Omega)	-	-	?	-	-	?	
Biological							
Bacillus pumilis (Sonata)	-	-	-	-	*	?	
Bacillus subtilis (Kodiak FL) [a]	P-F	?	-	-	-	-	Seed treatment
Bacillus subtilis (Serenade MAX)	-	-	-	-	?	-	
Coniothyrium minitans (Contans WG)	-	-	-	-	-	P	Useful if used in conjunction with other tools
Trichoderma harzianum (T-22 Planter Box) [a]	-	?	-	-	-	-	Seed treatment
Cultural / Non-Chemical							
Crop rotation	G	G	P	-	-	G	
Deep plowing prior to planting	?	?	?	-	-	?	
Fertilizer management (avoid excessive)	-	-	P-G	-	-	P-G	
Increased plant and row spacing (>30")	-	-	G	-	F	G	
Irrigation management	-	-	G	-	F	G	
Resistant cultivars	-	-	?	-	-	?	
Weed management	-	-	*	-	*	*	

Efficacy Ratings for WEED Management Tools in Processed Snap Beans

Rating scale: E = excellent (90-100% control); **G** = good (80-90% control); **F** = fair (70-80% control); **P** = poor (<70% control); **?** = efficacy unknown, more research needed; **-** = not used for this pest; ***** = used but not a standalone management tool. Note**:** Weed size or stage of growth is an important consideration with most post-emergence herbicides. In "Type" column, Pre = soil-active against pre-emerged weeds, Post = foliar-active against emerged weeds.

		ANNUAL BROADLEAVES															PERENNIAL BROADLVS			GRASSES					
MANAGEMENT TOOLS	Type	Fluvellin	Groundsel	Knotweed	Lambsquarters, common	Mayweed/Dogfennel	Mustards	Nightshade, black	Nightshade, hairy	Pigweeds	Prickly lettuce	Puncturevine	Purslane	Smartweed / Ladysthumb	Sowthistle	Wild buckwheat	Canada thistle	Field bindweed	Nutsedge	Annual ryegrass	Barnyardgrass	Crabgrass	Wild-proso millet	Quackgrass (perennial)	**COMMENTS**
Registered Chemistries																									
Bentazon (Basagran)	Post	P	F	G	F	F	F	P	F	P	P	?	G	E	P	G	G	F	P	-	-	-	-	-	Broadleaf weeds only
Clomazone (Command)	Pre	?	G	G	F	G	G	F	F	F	?	?	G	P	F	P	P	F	P	F	G	F	P	P	
DCPA (Dacthal)	Pre	?	?	P	G	?	P	P	P	F	?	?	?	F	?	P	P	P	P	P	F	G	P	P	
EPTC (Eptam)	Pre	?	G	G	G	G	G	G	G	F	G	?	G	P	G	F	P	F	P	E	E	G	G	E	
Glyphosate (Roundup)	Post	F	E	G	E	E	E	E	E	E	E	?	E	E	E	G	E	F	F	E	E	E	E	G	
Halosulfuron (Sandea)	Pre	?	?	G	E	F	G	P	P	G	F	?	P	F	P	?	?	?	P	P	P	?	?	?	
Imazamox (Raptor) + bentazon	Post	?	F	P	G	P	E	E	E	E	P	?	G	G	F	F	?	F	P	G	G	P	G	?	Raptor allowed as a tank mix only
Lactofen (Cobra)	Pre	P	F	P	F	E	G	E	E	E	G	?	G	P	G	F	P	F	P	P	P	P	P	P	OR only (supplemental label)
Metolachlor (Dual Magnum)	Pre	P	G	G	P	G	G	P	P	G	G	?	G	P	F	F	P	F	G	G	G	G-E	F	P	
Paraquat (Gramoxone)	Post	P	G	F	G	G	P	G	G	G	G	?	P	G	G	G	P	P	P	F	P	F	P	P	
Pelargonic acid (Scythe)	Post	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	P	P	P	P	P	F	P	P	
Pendimethalin (Prowl)	Pre	?	F	G	E	P	G	P	P	G	G	?	G	G	P	F	P	P	P	E	G	E	G	P	
Quizalofop P-ethyl (Assure II)	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	G	E	G	E	G	Grasses only
Sethoxydim (Poast)	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	G	E	G	E	G	Grasses only
Trifluralin (Treflan)	Pre	?	G	G	G	P	P	P	P	G	G	?	G	F	P	G	P	F	P	E	G	G	G	E	
Unregistered / New Chemistries																									
Clethodim (Select)	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	G	G	G	G	F	Grasses only
Dimethenamid-P (Outlook)	Pre	P	G	F	P	G	F	G	G	E	F	F	G	F	F	F	P	P	F	E	E	E	G	F	
Flufenacet (Axiom)	Pre	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
Fomesafen (Flexstar)	Post	?	G	G	F	?	G	G	G	G	?	?	?	?	?	?	P	P	P	P	P	P	P	P	

		ANNUAL BROADLEAVES															PERENNIAL BROADLVS			GRASSES					
MANAGEMENT TOOLS	Type	Fluvellin	Groundsel	Knotweed	Lambsquarters, common	Mayweed/Dogfennel	Mustards	Nightshade, black	Nightshade, hairy	Pigweeds	Prickly lettuce	Puncturevine	Purslane	Smartweed / Ladysthumb	Sowthistle	Wild buckwheat	Canada thistle	Field bindweed	Nutsedge	Annual ryegrass	Barnyardgrass	Crabgrass	Wild-proso millet	Quackgrass (perennial)	**COMMENTS**
Rimsulfuron (Matrix)	Pre & Post	?	F	F	G	F	F	F	F	G	?	?	F	F	F	F	P	P	P	P	P	P	P	P	
Biological																									
None																									
Cultural (Non-Chemical)																									
Cover crop [x]		?	P	P	G	F	P	G	G	G	P	-	G	P	P	?	-	-	-	P	P	G	P	-	
Crop rotation		?	F	F	F	F	F	F	F	F	P	F	F	F	F	?	F	F	F	G	F	F	G	F	Assumes effective herbicide use in the rotation crop
Cultivation		?	G	F	G	G	G	G	G	G	G	G	P	P	G	?	P	P	P	G	F	F	F	P	
Equipment sanitation		?	P	F	F	F	F	F	F	F	P	G	P	P	P	?	P	P	G	G	F	F	G	P	
Flaming		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	Used in conjunction with stale seedbed technique by some organic growers
Hand hoeing/hand pulling		?	G	G	G	G	G	G	G	G	F	G	P	P	G	?	P	P	P	G	F	P	F	P	
Stale seed bed		?	F	P	F	P	F	F	F	G	P	P	P	P	P	?	-	-	-	P	F	P	F	-	Not common

[x] Assumes substantial residue left on the soil surface in no-till or strip-till situations. Cover crops actively growing during the winter help suppress winter annual broadleaf weeds, only, which are not a major concern in snap bean production.

Toxicity Ratings for Beneficials in Oregon and Washington Processed Snap Beans

Key to Beneficials:
BEB = Bigeyed bug (*Geocoris pallens*)
CB = Carabid beetles (Carabidae family) and Rove beetles (Staphylinidae family)
DB = Damsel bug (*Nabis alternatus*)
HB = Honey Bee (*Apis mellifera*) and Bumble bee (*Bombus* spp.)
LW = Lacewings (*Chrysopa* spp.)
LB = Lady beetles (*Coccinella septempunctata*, *Harmonia axyridis*, *Hippodamia convergens*)
MPB = Minute pirate bugs (*Orius* spp.)
PM = Predatory mites (Acari: Phytoseiidae)
PW = Parasitic wasps (Ichneumonidae and Braconidae families)
S = Spiders (Arachnida:Araneae*;* Linyphiidae and Tetragnathidae families)
SF = Syrphid flies (Syrphidae family)
TF = Tachinid flies (Tachinidae family)

Rating Scale: O = Non-toxic; **L** = Slightly toxic; **M** = Moderately toxic; **H** = Highly toxic; **ND** = No Data

	BEB	CB	DB	HB	LW	LB	MPB	PM	PW	S	SF	TF	**Comments**
Registered Material:													
Insecticides / Miticides:													
Bacillus thuringiensis (Bt)	O		O	O	O	O	O	O	O	O	O	O	
Bifenthrin (Capture)	M		H	H	M	H	H	H	H	H	H	H	
Carbaryl (Sevin)	M		M	H	M	H	M	H	M	M	M	M	
Chlorpyrifos (Lorsban)seed trt	O	O	O	O	O	O	O	O	O	O	O	O	
Diazinon seed trt													
Dicofol (Kelthane)	M	M	M	L	M	M	M	H	M	M	M	M	
Endosulfan	M	M	M	M	M	M	M	L	M	M	M	M	
Esfenvalerate (Asana)	M		H	O	M	H	H	H	H	H	H	H	
Ethoprop (Mocap)	L	L	L	L	L	L	L	L	L	L	L	L	
Imidacloprid (Gaucho 480) seed trt	O	O	O	O	O	O	O	O	O	O	O	O	
Lambda-cyhalothrin (Warrior)	M-H		M-H	O	M-H	M-H	M-H	H	M-H	H	M-H	M-H	
Malathion	M		M	H	M	H	M	H	M	M	H	M	
Methomyl (Lannate)	H		H	H	H	H	H	H	ND	M	H	H	
Pyrethrin + rotenone (Pyrellin)	M		M	O	L-M	M	M	H	M	H	M	M	
Soaps (M-Pede)	L	L	L	L	L	L	L	L	L	L	L	L	No data but general mode of action may prove toxic to leaf-borne beneficials
Spinosad (Success)	M		M	M	M	M	M	M	M	M	M	M	
Thiamethoxam (Cruiser) seed trt	O	O	O	O	O	O	O	O	O	O	O	O	
Fungicides:													
Azoxystrobin (Amistar, Quadris)													ND
Azoxystrobin (Dynasty, Protégé) seed trt													
Bacillus pumilis (Sonata)	O	O	O	O	O	O	O	O	O	O	O	O	
Bacillus subtilis (Kodiak FL) seed trt													
Bacillus subtilis (Serenade MAX)	O	O	O	O	O	O	O	O	O	O	O	O	
Boscalid (Endura)													ND
Captan (Captan 400) seed trt	O	O	O	O	O	O	O	O	O	O	O	O	
Carboxin (Vitavax-34) seed trt													
Chlorothalonil (Bravo, Terranil, others)													ND
Coniothyrium minitans (Contans WG)													
Copper (Champ, Kocide)	ND		ND	ND	ND	ND	ND	L	ND	ND	ND	ND	

	BEB	CB	DB	HB	LW	LB	MPB	PM	PW	S	SF	TF	Comments
Dichloran (Botran 75W)													ND
Fludioxonil (Maxim 4FS) seed trt													ND
Iprodione (Rovral)	ND		ND	ND	ND	ND	ND	L	ND	ND	ND	ND	
Mefenoxam (Apron) seed trt													
Mefenoxam (Ridomil Gold)	ND		ND	ND	ND	ND	ND	L	ND	ND	ND	ND	
Metalaxyl (Allegiance FL) seed trt													
Myclobutanil (Rally)													ND
Pentachloronitrobenzene (PCNB 2-E)													
Pentachloronitrobenzene (RTU-PCNB) seed trt													
Pyraclostrobin (Headline)													ND
Streptomycin (AgStrep) seed trt													
Thiophanate-methyl (Topsin-M)													ND
Thiram (Thiram 42-S) seed trt													
Trichoderma harzianum (T-22) seed trt													
Vinclozolin (Ronilan)													
Herbicides:													
Bentazon (Basagran)													ND
Clomazone (Command)													
Dichloran (Dacthal)													ND
EPTC (Eptam)													
Gyphosate (Roundup, others)	M		ND	ND	ND	ND	ND	H	L	ND	ND	ND	
Halosulfuron (Sandea)													
Imazamox (Raptor)													
Lactofen (Cobra)													
Metolachlor (Dual Magnum)													ND
Paraquat (Gramoxone)	ND		ND	ND	ND	ND	ND	H	ND	ND	ND	ND	
Pelargonic acid (Scythe)													ND
Pendimethalin (Prowl)													ND
Quizalofop P-ethyl (Assure II)													
Sethoxydim (Poast)													ND
Trifluralin (Treflan)	ND		ND	ND	ND	ND	ND	ND	M-H	ND	ND	ND	
Unregistered / Potential chemistries													
Insecticides/Miticides:													
Acetamiprid (Assail)													
Buprofezin (Applaud)													
Indoxacarb (Avaunt)													
Fipronil (Regent) seed trt													
Fipronil (Regent)													
Methoxyfenozide (Intrepid)	M?		M?	ND	ND	ND	ND	ND	O	ND	ND	ND	Low probability of harm to beneficials
Novaluron (Diamond)													
Pyriproxyfen (Esteem)	M		M	O	ND	ND	ND	L-M	M	ND	ND	ND	
Thiamethoxam (Platinum) soil-applied													Low probability of harm to beneficials
Thiamethoxam (Actara) foliar	L		L	M	L	L	L	L-M	L-M	L	L	L	
Fungicides:													
Cyprodinil + fludioxonil (Switch)													ND
Fluazinam (Omega)													
Herbicides:													
Clethodim (Prism)													ND
Dimethenamid-P (Outlook)													ND

	BEB	CB	DB	HB	LW	LB	MPB	PM	PW	S	SF	TF	**Comments**
Flufenacet (Axiom)													
Fomesafen (Reflex)													
Rimsulfuron (Matrix)													
Biological:													
None													
Cultural / Non-Chemical:													
Cover crops													Provides good habitat, shelter and alternative prey for the beneficials
Crop rotation													Largely neutral
Cultivation, tillage, plowing													Short term disruption to soil dwellers
Equipment sanitation													Neutral
Hand hoeing	H		H	H	H	H	H	H	H	O	H	H	Hazardous to foliage dwellers
Irrigation management													Neutral
Nutrition management (no excess)													Neutral
Resistant/tolerant cultivars													Neutral
Row spacing (increased)													Neutral
Trap crops													
Weed control													May remove habitat or alternative prey for some species