1996

Best Management Practices for Integrated Pest Management in the San Luis Valley

Potato

San Luis Valley

WATER QUALITY

Demonstration Project

#XCM-196

The mission of the San Luis Valley Water Quality Demonstration Project is to *promote the adoption of water quality conservation Best Management Practices to minimize agricultural non-point source pollution of water resources in the San Luis Valley.*

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Preface and Acknowledgments

Shallow water tables, coarse soils and intensive agricultural production systems increase the risk of agricultural non-point source pollution of water resources in the San Luis Valley of south central Colorado. In 1991, the U.S. Department of Agriculture authorized the San Luis Valley Water Quality Demonstration Project to address the issues of this risk.

The San Luis Valley Best Management Practices (BMP) Advisory Committee was formed to identify and document BMPs for selected high-risk crops. The committee consists of a cross-section of local agricultural producers, crop consultants, fieldmen, and local government agency specialists.

The Project offers sincere thanks to the committee for their willingness and dedication to serve, advise and support the local BMP process to conserve the quality of local water resources.

Special acknowledgment is given to the following Colorado State University Cooperative Extension personnel: Dr. Richard Zink, potato specialist; Dr. Robert Davidson, manager, Potato Certification Service; Dr. Scott Nissen, weed specialist; Dr. Whitney Cranshaw, entomologist; Reagan Waskom, water quality specialist.

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Publication Guide

BMP Identification and Implementation

The development of water conservation Best Management Practices (BMPs) is a process of identifying and implementing cultural and structural practices to minimize agricultural non-point source water pollution. The focus ranges from a regional perspective to an individual farming operation.

Important aspects of these practices are economical and environmental soundness. Just as the water quality concerns have site-specific characteristics, local BMPs are selected to be suitable for local adoption. Often, these practices are already in place.

Critical to the success of the BMP approach is voluntary adoption by producers. Local agricultural producers are inherently concerned about the resources they manage while making a living. Therefore, BMPs are best identified by those who understand the local situation and will be implementing the practices.

Broad regulatory action does not hold the promise of the more tailored BMP process. However, BMPs need to be widely adopted in a region to be effective in addressing water quality concerns. Otherwise, regulatory intervention may become necessary.

IPM-BMP Selection

Integrated Pest Management (IPM) definitions have varied since the development of the concept in the 1950s. Implementation of an IPM system is based on understanding the biology and environment of a pest, then managing the pest with an integrated means of control.

The ideal fulfillment of IPM results in limiting a pest's impact through a combination of physical, biological, and chemical means that are safe, economical, environmentally sound, socially tolerable, efficient, and effective. Therefore, IPM is not a fast solution but instead a long-term process that includes scouting and planning, as well as treatments of an immediate problem.

The linking of water quality conservation BMPs and IPM offers a natural combination of deliberate, acceptable solutions to both pest and water quality concerns for the San Luis Valley.

Explanation of Pest Pages

The following pest and management descriptions for diseases and insects are presented with three sections.

Impact: Offers general information on common locations of infestations, degree of spread and potential effects of a typical infestation in the San Luis Valley.

Description and Symptoms: Describes how the pest is manifested in the San Luis Valley including typical pest appearance and influence on the plant to assist in scouting efforts.

Integrated Management: Presents the management options best suited for San Luis Valley conditions.

The weed management description has a checklist for integrated weed management offering general information and a chart for specific recommendations for common weeds.

Table of Contents

Checklist for Healthy Potato Production

Healthy potato plants are the best prevention against disease, insect, and weed problems.

☑ Planning

➤ Establish permanent records of fertility, weed infestations, crop rotation, cultural practice, and pesticide use for each field.
➤ Select cultivars appropriate for production conditions.
➤ Establish an appropriate crop rotation.
➤ Manage potato fields to avoid soil compaction, herbicide carryover, volunteer potatoes and grain.
➤ Monitor fields for soilborne diseases and apply pesticides if necessary and economically feasible.
➤ Sample soil and irrigation water for fertility, pH and other factors.

☑ Field Preparation

➤ Proper placement of preplant fertilizer is critical to efficient utilization and to avoid root damage and excess leaching.
➤ Apply preplant fertilizers and soil amendments as indicated by the results of soil and irrigation water analysis.
➤ Perform tillage operations necessary to manage weeds and crop residues, minimize erosion and provide proper soil tilth for planting.
➤ Pre-irrigate soil if seed bed is dry.

☑ Seed Handling and Planting

➤ Clean and sanitize storage facilities and seed-handling equipment prior to receiving seed potatoes and as often as possible thereafter.
➤ Always use certified seed.
➤ Examine seed tubers for diseases and defects prior to purchase and upon delivery.
➤ Handle and store seed properly to maintain tuber health.
➤ Do not hold seed in storage areas that have been treated with a sprout inhibitor and may still contain residue.
➤ Adjust seed-cutting operations to ensure uniform and properly sized seed pieces.
➤ Delay planting until soil temperatures are above 50° F at the 6-inch depth, typically after May 1.
➤ Establish sufficient soil moisture in the root zone prior to or immediately after planting to provide adequate available water until the potato plants are fully emerged. **Post-plant irrigation poses a serious threat of seed piece decay when using cut seed.**
➤ Sanitize during cutting or at least prior to cutting each seed lot.
➤ Apply a seed-piece fungicide treatment as needed.
➤ Provide proper conditions for cut seed to suberize, or when soil conditions permit, plant immediately after cutting. Suberization time varies greatly depending on cultivar.
➤ Adjust the planter so seed pieces are planted at the intended spacing and depth for a specific cultivar.
➤ Dispose of cull piles.

☑ Post-plant/Preemergence

➤ Check soil moisture and seed condition.
➤ Begin weed scouting.
➤ Perform operations for preemergence weed control and/or any cultural practices that reduce soil crusting and promote rapid emergence.
➤ Avoid excessive irrigation prior to emergence.

☑ Vegetative Growth

➤ Provide adequate and uniform soil moisture based on crop water use.
➤ Apply post-emergence herbicides and/or use cultural practices as necessary.
➤ Complete hilling/cultivating operations well before row closure to avoid root pruning.
➤ Begin insect and disease scouting.
➤ Delay fungicide or insecticide application until the action threshold for the target pest or disease has been reached.

☑ Tuber Initiation and Bulking

➤ Continue to provide adequate and uniform soil moisture based on crop water use.
➤ Begin petiole analysis for nutritional management when plants are 6 to 8 inches tall. Apply nutrients as needed.
➤ Continue insect scouting and disease monitoring and apply pesticides as necessary.

☑ Tuber Maturation

➤ Avoid excessive late season irrigation to minimize tuber diseases.
➤ Promote tuber skin set and minimize nitrogen residue by avoiding nitrogen applications after mid-August. This date may be earlier depending on the cultivar.
➤ Schedule vine-killing operations to allow complete desiccation of the vines and good skin set before harvest. Maturation time varies depending on cultivar.
➤ Continue foliar applications of fungicides and insecticides, if appropriate, until the vines are completely dead.
➤ Inspect, repair, and sanitize storage facilities and harvest equipment.

☑ Harvest

➤ Conduct all harvesting, transportation, and bin-loading operations with bruise management as a primary goal.
➤ Avoid harvesting when tuber pulp temperatures are below 45° F and above 70° F. Cultivars vary in susceptibility to damage.
➤ Tarp loads in the field to protect harvested tubers from rain, direct sun, desiccation, and adverse temperatures during long distance transport.
➤ Remove all soil, decaying tubers and debris from tubers during bin loading to facilitate air flow in the pile.
➤ Size tubers during bin loading to minimize future handling.
➤ Apply a fungicide at this time to control potential storage diseases.

☑ Storage

➤ Manage the curing period carefully to provide appropriate conditions for wound healing.
➤ Promote suberization and wound healing by maintaining the following conditions: 50° to 60° F, relative humidity 95 to 99 percent, and good air movement.
➤ Lower storage temperatures to appropriate levels for long-term storage, depending on the end use of the crop.
➤ Monitor the pile for signs of decay. Take appropriate action if decay develops.
➤ Manage the storage to address abnormal tuber conditions, such as frost, leak and soft rots.

Scouting: Key to success in IPM

Field scouting is important for identifying pest problems before they get out of control. Successful IPM depends on monitoring each field individually for potentially damaging pest outbreaks.

The tools for a thorough scouting program include: soil and tissue monitoring; pheromone, sticky, or pan traps; hand lenses; sweep net; visual observations; and, a good system of field records and maps. To scout for pests:

- Acquire and understand use of equipment;
- Record each trip to the field;
- Scout each crop, variety and field;
- Visit each field daily;
- Use all appropriate scouting methods:
  Insects - regional monitoring reports, observation, leaf and stem sampling, and sweep net sampling;
  Diseases - field history, observation, plant tissue sampling, and soil sampling;
  Weeds - field history and observation;
- Follow the proper re-entry guidelines for fields treated with pesticides; and,
- Seek assistance from your nearest Colorado State University Cooperative Extension office or local crop adviser when necessary.

Bacterial Ring Rot

Plant certified seed potatoes.

Impact

Bacterial ring rot (BRR) is caused by the bacterium *Clavibacter michiganensis subsp. sepedonicus*. BRR is a serious disease of potato. Presence in seed will result in rejection of lots for certification.

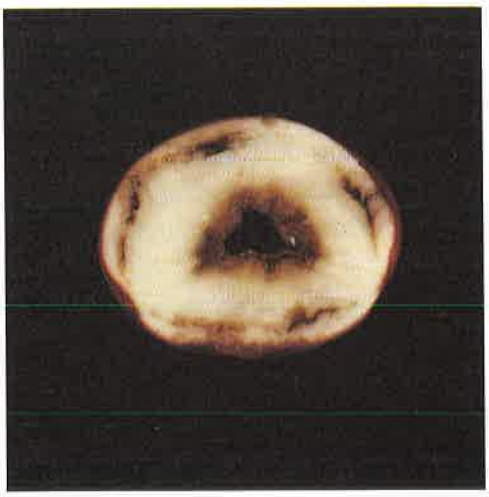
The bacteria overwinter mainly in infected seed tubers. BRR is capable of surviving more than five years in dried slime on the surfaces of crates, bins, burlap sacks, and harvesting and grading machinery. Survival is possible even if exposed to temperatures well below 0° F. BRR survives longest under cool, dry conditions.

BRR occurs sporadically in the San Luis Valley.

Description and Symptoms

➤ Foliar symptoms usually appear late in the growing season. Cultivars differ greatly in their expression of the disease.
➤ Symptoms include: early dwarfing, rosetting of upper leaves and general wilting of the plant with chlorosis and necrosis of the leaves.
➤ Stems of plants, when cut at the base, produce a milky exudate upon squeezing. Commonly, only one or two stems develop symptoms.
➤ Infected tubers often develop a creamy yellow to light brown rot in the vascular ring.
➤ BRR readily spreads between tubers during seed cutting and handling.
➤ Tubers and plants may be symptomless even though they are infected with BRR.

Bacterial ring rot foliar symptoms.



Bacterial ring rot tuber symptoms.

Integrated Management

- Plant certified seed potatoes.
- **Never** plant contaminated seed lots.
- Avoid cutting seed tubers and using pick-type planters.
- Maintain strict sanitation aimed at eliminating BRR from all production surfaces. A complete sanitation program involves thoroughly washing all surfaces with a detergent applied by a high-pressure washer, rinsing with clean water and sanitizing with a suitable disinfectant for a minimum of 10 minutes under ideal conditions.
- Undertake a thorough cleanup and sanitation of any farm with confirmed BRR in potato stocks to reduce risk of carryover into next year's crop. Dispose of infected tubers and cull piles as soon as possible.
- Salvage a commercial crop with a low level of BRR by an integrated management approach involving delayed harvest, careful grading to remove any decayed tubers when the crop is placed in storage, and proper storage management. **Do not save seed to replant.** Market potatoes as soon as possible.
- No resistant cultivars and pesticide control are available.

Seed Piece Decay and Blackleg

Plant undamaged, whole seed tubers which are less susceptible to bacterial seed piece decay.

Blackleg.

Impact

The causal agent is *Erwinia carotovora* subspp. *carotovora* and *atroseptica.* Occurrence of these diseases is influenced by seasonal environment.

The San Luis Valley certified seed industry strives to minimize outbreaks by using tissue-culture derived stocks coupled with a limited generation system and a complete disease testing program.

Description and Symptoms

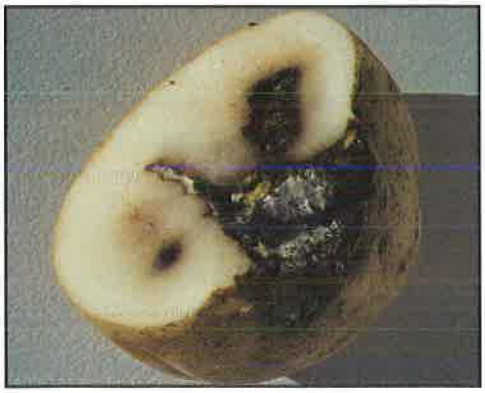
➤ Bacteria are carried on seed tubers, mainly in the lenticels, in a dormant state. When environmental conditions are favorable, disease expression may occur.
➤ High soil temperatures and bruising of seed tubers, or cool, wet and poorly aerated soils at planting, favor seed piece decay and pre-emergence blackleg. Cool, wet soils at planting, followed by high temperatures after emergence, favor post-emergence blackleg. Fusarium seed piece decay may predispose developing plants to infection by the soft rot Erwinias, resulting in increased soft rot of seed pieces and early-season blackleg.
➤ In severe cases, entire seed pieces and developing sprouts decay prior to emergence, resulting in uneven stands.
➤ In post-emergence blackleg, the basal stem area of diseased plants typically exhibit an inky black to light brown decay.

Integrated Management

- Conduct a thorough sanitation program throughout the entire farming operation.
- No resistant cultivars are available. However, cultivars vary in susceptibility to the disease.
- No pesticide control is available.
- Plant high quality, tissue-culture derived, certified seed to minimize seed-borne contamination.
- Plant undamaged, whole seed tubers that are less susceptible to bacterial seed piece decay. When cut seed is used, thoroughly clean all seed-cutting and handling equipment between seed lots to minimize the spread of bacteria. Warm seed tubers to about 45° to 55° F before cutting. Wound healing and suberization are critical for prevention of infections by soft rot Erwinias.
- Plant seed pieces in adequate soil moisture when temperatures are at least 50° F at a 6-inch depth.

Fusarium Dry Rot and Seed Piece Decay

Manage harvest procedures and storage operations to minimize bruising and to promote rapid healing of harvest wounds.



Fusarium dry rot.

Impact

Fusarium dry rot is caused by several common species of the soilborne fungus *Fusarium*. Fusarium dry rot causes losses in storage of both seed and commercial potatoes. It is a potential cause of seed piece decay after planting.

Disease incidence varies from season to season in the San Luis Valley.

Description and Symptoms

➤ Small, brown lesions at wound sites occur three to four weeks after harvest and continue to enlarge during storage.
➤ Infected areas of tubers are sunken or wrinkled. Rotted tissues are brown or gray to black.
➤ Internal cavities often develop in rotted tissues and contain white, yellow or pink mycelium that are visible when tubers are cut.
➤ At low storage temperatures, internal tissues often become firm and dry or even powdery.
➤ Infection proceeds rapidly at temperatures above 50° F, but ceases and is dormant if the temperature is lowered to 40° F.
➤ Poor stands may result from seed piece decay, especially if the cut surfaces of the seed pieces are not properly suberized.
➤ A slimy rot often develops when secondary soft rot bacteria become established.

Integrated Management

- Manage harvest procedures and storage operations to minimize bruising and to promote rapid healing of harvest wounds.
- Apply fungicides to tubers that will be stored if Fusarium dry rot is anticipated.
- Manage bin filling to minimize soil and debris in the pile.
- Hold newly harvested potatoes at 50° to 60° F and 95 to 99 percent relative humidity to promote rapid wound healing. Following the curing period, lower temperatures to a level appropriate for long-term storage.
- Treat cut seed tubers with a fungicide, if justified. Plant immediately under appropriate field conditions, or allow to suberize at 55° to 60° F and 95 to 99 percent relative humidity for at least 72 hours.
- Avoid cutting seed tubers and the use of pick-type planters.

Late Blight

Imported seed or commercial potatoes pose a rapidly increasing risk because of the recent late blight epidemic.

Late blight foliar symptoms (G. A. Secor, North Dakota State University).

Impact

Late blight is caused by the fungus *Phytophthora infestans.* Late blight is one of the most devastating diseases of potato worldwide. This disease is most serious where the weather is consistently cool and humid. In recent years, epidemics of late blight have developed in crops under center-pivot irrigation in arid production areas.

Late blight has occurred twice over the last 20 years in the San Luis Valley as a result of imported seed. Imported seed or commercial potatoes pose a rapidly increasing risk because of the recent North American late blight epidemic.

Description and Symptoms

➤ Symptoms of late blight appear on leaves as pale-green, water-soaked spots, usually beginning at the leaf tips or edges. The circular or irregularly shaped lesions are often surrounded by a pale, yellowish-green border. The lesions enlarge rapidly and turn brown or purplish black.
➤ During periods of high relative humidity and leaf wetness, lesions may be bordered by a cotton-like white mold growth on the underside of the leaf.
➤ In dry weather, infected leaf tissues turn brown and quickly dry up. Infected stems and petioles turn brown to black, and entire vines may be killed.
➤ Under cool, moist conditions, the fungus can form spores on the foliage of infected plants. These spores are easily dislodged and can be moved by the wind into neighboring potato fields and cause new infections.
➤ On the tuber surface, lesions appear brown and sunken while tissues immediately beneath appear granular and tan to copper-brown.
➤ The fungus survives between crops in infected tubers. Tubers removed during grading and dumped in cull piles or unharvested tubers in the fields or rock piles are sources of the pathogen.
➤ Newer strains of the fungus are more aggressive, resulting in a higher incidence of tuber infection. Infection can occur on other *Solanaceous* species such as pepper, tomatoes and various nightshade species.

Integrated Management

- **Do not import seed potatoes or commercial potatoes.**
- Scout fields weekly after emergence until harvest.
- Apply fungicides to all fields after confirmation of late blight in the San Luis Valley. Continue applications at recommended intervals for the remainder of the season. Complete coverage of all foliage with a fungicide is essential. Ground application is most effective. Fungicide applications should continue until vines are dead.
- Harvest only after vines are completely dead. Handle tubers gently to avoid mechanical damage and to reduce the risk of infection.
- Avoid harvesting under wet conditions. If wet tubers are harvested, steps must be taken to remove free moisture from their surfaces quickly.
- Dispose of cull piles promptly.

Early Blight

Early blight is a very common and economically serious disease that occurs annually in the San Luis Valley.

Early blight foliar symptoms.

Early blight tuber symptoms.

Impact

Early blight is caused by the fungus *Alternaria solani*. Foliar infections can greatly reduce leaf area, limiting tuber yields.

Early blight is a common and economically serious disease that occurs annually in the San Luis Valley.

Description and Symptoms

➤ Leaf lesions are circular and dark with a yellow border. As lesions expand, an angular appearance develops due to confinement by the leaf veins.
➤ Target-like or concentric rings of raised and lowered dead tissue are typical in large lesions.
➤ Infection usually begins on older, lower leaves and moves slowly into the upper canopy.
➤ Tubers are infected at harvest by fungal spores present on the soil surface.
➤ Tuber lesions are circular to irregular-shaped, slightly sunken and dark-colored with a raised purple to brown border. Tuber tissue under the lesion is dark and dry, appearing corky or leathery.
➤ After extended storage of infected tubers, moisture loss from the lesions can result in shrivelling.
➤ Early blight spores overwinter in soil, crop residue and on infected tubers.

Integrated Management

- Manage the crop for optimal crop fertility and soil moisture to slow disease development.
- Scout for foliar lesions at emergence and continue weekly.
- Monitor degree-day reports provided by Colorado State University Cooperative Extension to determine timing of fungicide application.
- Apply fungicides uniformly to the plant canopy. Fungicides are not available to treat tuber infection on commercial potatoes.
- Minimize tuber injuries to limit tuber infection. Proper skin set is the most important barrier to infection.
- Cool storages rapidly if tuber infections are anticipated. Keep in mind conditions favoring suberization also favor tuber blight development.
- Manage storage to avoid free water on structural surfaces.

Silver Scurf

Use high-quality, certified seed. Note: this practice will not offer 100 percent control.

Silver scurf.

Impact

Silver scurf, caused by the fungus *Helminthosporium solani,* is a common disease in most potato producing areas. Silver scurf can drastically lower market quality of tubers. This disease is difficult to manage.

As a result of imported seed, silver scurf has become a more important disease in the San Luis Valley in recent years.

Description and Symptoms

➤ Spread of the fungus to daughter tubers is largely from infected seed pieces; soil transmission also is a factor.
➤ Infections become more severe the longer the tubers remain in the soil.
➤ Infections occur in the field as tubers mature. Symptoms may be present on tubers at harvest or may develop on tubers in storage.
➤ Infected areas have a distinct silvery sheen, particularly if the surface is wet.
➤ Infected tubers will shrivel during storage from excessive water loss.
➤ High humidity and temperatures above 40° F foster silver scurf development in storage.
➤ Tuber to tuber spread in storage is common.

Integrated Management

- Use high-quality, certified seed. Note: this practice will not offer 100 percent control.
- Harvest as soon as adequate skin set has been achieved.
- Ventilate storage areas with cool air for drying. Store tubers at the lowest possible temperature consistent with the intended end use.
- No pesticides are presently available for effective control.
- Rotate crops and potato cultivars.

Pink Rot and Pythium Leak

Leak and pink rot in susceptible cultivars are most severe in the San Luis Valley when warm, wet conditions prevail late in the growing season.

Pink rot (Robert Davidson).

Pythium leak.

Impact

Pink rot is caused by the soilborne fungus *Phytophthora erythroseptica.* Pythium leak is caused by several species of a closely related soilborne fungus *Pythium.* Pink rot and Pythium leak sometimes are collectively called water rot or leak.

These diseases usually are of economic concern when tubers are exposed to saturated soils for several days in succession during maturation and soil temperatures are above 70° F.

Leak and pink rot in susceptible cultivars are most severe in the San Luis Valley when warm, wet conditions prevail late in the growing season.

Description and Symptoms

Pink Rot

➤ The pathogen can enter tubers through diseased stolons. Tuber infections also occur at eyes and lenticels.

➤ The decay spreads through infected tubers quickly. The advancing margin of the rot is sharply defined by a dark line, which may be visible through the skin.

➤ Decaying tubers remain intact, are spongy and have a distinct odor. If squeezed, a clear liquid exudes.

➤ The internal tissue of a cut tuber turns salmon pink after exposure to the air for 15 to 20 minutes then turns brownish black.

Pythium Leak

➤ Tuber wounds during harvest and handling are the main infection sites for Pythium. The disease begins as a discolored, water-soaked area.

➤ As with pink rot, the advancing margin of the rot usually is bound by a dark line.

➤ The most characteristic tuber symptom is an extremely watery condition of diseased tissues, which turn brown or gray.

Integrated Management

- Rotate crops out of potatoes for at least four years to reduce *Phytophthora* and *Pythium* levels in the soil. Select well-drained fields and avoid excessive irrigation in the weeks prior to harvesting highly susceptible cultivars.
- Apply a systemic fungicide on susceptible cultivars when a field has a history of pink rot.
- Delay harvest when pulp temperatures are above 70° F. Pick up windrowed tubers quickly and tarp loads to avoid overheating during warm harvest conditions.
- Store diseased lots separately from healthy lots. Keep temperatures below 45° F. Provide good air flow to dry and cool infected tubers. Market diseased lots quickly or directly from the field.
- If considerable pink rot is present in the field, delay harvest to allow the full development of symptoms in infected tubers so they can be graded out before the crop is placed in storage.

Potato Early Dying

Fields continuously cropped with potatoes are common sites of the disease.

Verticillium wilt.

Impact

Potato early dying is predominantly caused by the soilborne fungus *Verticillium dahliae* in the San Luis Valley. The disease is characterized by premature vine death and declining yields. Fields continuously cropped with potatoes are common sites of the disease.

Potato early dying is rarely a problem in the San Luis Valley due to the cool environmental conditions and short growing seasons.

Description and Symptoms

➤ Symptoms of potato early dying are difficult to distinguish from normal senescence. Infected plants may only initially exhibit retarded growth.
➤ Foliar symptoms appear as uneven chlorosis and some wilting of the lower leaves.
➤ Areas between leaf veins turn yellow and later brown, often at the leaf tip first.
➤ Leaf yellowing and death proceed up the stem, which usually remains erect.
➤ A tan discoloration of the vascular tissues usually can be seen when a stem is cut in a cross section near its base.
➤ Noninfested fields can become contaminated with *Verticillium* carried in or on the surface of seed tubers or in soil particles transported by the wind or by mechanical means. Once established in a field, the fungus will persist in the soil for several years.
➤ *Verticillium* can be maintained at a low population in the roots of many symptomless crop and weed species.
➤ High populations of the root-lesion nematode, *Pratylenchus spp.*, in the presence of *Verticillium* can increase potato early dying .

Integrated Management

- Rotate out of potatoes for two or three years.
- Maximize yields by maintaining optimum fertility and providing adequate soil moisture to overcome the effects of Verticillium wilt in the field.
- Plant resistant cultivars. This is the most practical method for management of potato early dying. However, availability of resistant cultivars is limited.
- Avoid highly susceptible varieties which can increase the levels of *Verticillium* in the soil and result in higher soil inoculum levels.
- Apply soil fumigants to reduce populations of *Verticillium*. Fumigants do not completely eradicate the pathogen from infested fields. However, fumigation in the San Luis Valley appears to have long-term effects. Due to the high cost, base the decision to fumigate on the field history of early dying, cultivar to be grown, and on an assay of the soil to determine nematode and *Verticillium* populations.

Potato Leafroll Virus

Potato leafroll severity has been reduced in the San Luis Valley as a result of a comprehensive aphid suppression and monitoring program.

Potato leafroll virus symptoms.

Impact

Potato leafroll is caused by the potato leafroll virus. The severity of symptoms depends on the strain of virus, susceptibility of the cultivar, time of infection, and environment. Yield may be substantially reduced in plants grown from infected tubers.

Potato leafroll severity has been reduced in the San Luis Valley as a result of a comprehensive aphid suppression and monitoring program.

Description and Symptoms

➤ Leafroll is introduced by planting infected seed or by aphids carrying the virus to the field from an outside source.
➤ Leafroll is transmitted by several species of aphids. The green peach aphid is the primary vector in the San Luis Valley. Aphids acquire the virus after several hours of feeding and require an incubation period before being able to transmit the virus to non-infected plants. Once infected, the aphid usually retains the virus for life.
➤ Lower leaves of plants grown from leafroll-infected seed tubers become rolled and leathery and may turn light pink or yellow.
➤ Infected plants usually are stunted and more upright than healthy plants.
➤ Young leaves may become yellow or slightly pinkish and rolled and may stand upright in early current-season infections.
➤ Current-season infections that develop late in the season may cause no visible symptoms, but tubers usually become infected.
➤ Early season infections may reduce yield.

Integrated Management

- Plant high quality, certified seed.
- Check the weekly San Luis Valley green peach aphid monitoring reports at the San Luis Valley Research Center.
- Control aphid populations in the field, and on other hosts.
- Rogue infected plants early in the season to control disease sources in the field.
- Consider early vine-kill when high aphid populations are present.

Potato Virus X and Potato Virus Y

The Colorado seed certification program minimizes the impact of these viruses in the San Luis Valley by conducting an extensive testing program annually.

Severe mosaic symptoms.

Impact

Two potato mosaic viruses that are important in the San Luis Valley are Potato Virus X (PVX) and Potato Virus Y (PVY). PVX is known as potato latent virus disease, potato mottle or latent mosaic. PVY causes severe or rugose mosaic. PVY is reported to cause losses ranging from 10 to 80 percent, depending on the potato cultivar. The primary effect of both viruses is a reduction in yield and size of daughter tubers.

The Colorado seed certification program minimizes the impact of these viruses in the San Luis Valley by conducting an extensive testing program.

Description and Symptoms

PVX

➤ PVX usually causes few or no symptoms in most cultivars and can be carried in seed stocks unnoticed.

➤ PVX is readily transmitted mechanically. It is spread by foliar or sprout contact, seed cutters, pick-type planters, cultivators, spray equipment, and possibly by insects with chewing mouthparts.

➤ Some strains alone, or in combination with PVY, may cause rugose mosaic.

PVY

➤ PVY is a stylet-borne virus transmitted by at least 30 species of aphids, particularly the green peach aphid and potato aphids. Cereal aphids in high numbers become important vectors of PVY.

➤ Symptoms of PVY may vary by cultivar. Necrosis and veinal necrosis of petioles often cause leaves to drop or cling to the stems. Infected plants have bunchy tops and leafless lower stems or clinging necrotic leaves. In Russet Norkotah, visible symptoms do not become well developed.

➤ Aphids landing on infected plants acquire PVY within a few seconds of feeding and can transmit the virus immediately, in a non-persistent manner. While aphid transmission is the most important means of spread in the field, all PVY strains also are mechanically transmissible by leaf contact and may be carried in seed tubers.

➤ Current-season infection late in the growing season may not cause foliar symptoms.

Integrated Management

- Plant high quality, pathogen tested, certified seed.
- Conduct a strict sanitation program including use of detergents.
- Destroy volunteer potatoes which may harbor PVX or PVY.
- Avoid cutting seed that is extensively sprouted.
- Complete cultivation, hilling, and other post emergence operations when plants are less than 6 to 8 inches tall.
- Control of aphids is an important component of a management program for viruses. However, this action will not control PVY. Kill vines early to avoid late season aphid flights.

Rhizoctonia Canker

Rhizoctonia is sporadic throughout the San Luis Valley due to environmental influences.

Rhizoctonia stem canker.

Impact

Rhizoctonia canker and black scurf are caused by the soilborne fungus *Rhizoctonia solani*. The fungus survives in soil as mycelium associated with decomposing plant residues. In addition, the sclerotia can survive on infected tubers and can persist free in soils for extended periods.

Rhizoctonia is sporadic throughout the San Luis Valley depending on environmental conditions.

Description and Symptoms

➤ Brownish black, sunken lesions on underground stems and stolons are characteristic of Rhizoctonia canker.
➤ The disease may cause nonuniform stands and weak, spindly looking or late-emerging plants. Sprouts attacked before emergence are often killed, which leads to delayed emergence by weaker sprouts.
➤ Infected sprouts that do emerge, often remain stunted. Early-season infections frequently result in pruning of young stolons.
➤ Cool, moist soils, 55° to 60° F, are optimal for infection.
➤ Deep, sunken cankers may girdle main stems, causing yellowing, purpling, upward curling of leaves, and the formation of aerial tubers. These symptoms can be confused with symptoms of other diseases.
➤ The fungus forms individual sclerotia or masses of sclerotia on mature tubers, referred to as black scurf. Appearance varies from dark, netted or scurfy residues on tuber surfaces to individual black masses ranging from pinhead to pea-size.

Integrated Management

- Use high quality certified seed with low levels of Rhizoctonia black scurf, because tuber-borne inoculum is most likely to result in serious sprout infection.
- Rotate out of potatoes preferably to a small grain, to slow fungal population development.
- Plant early to limit stem infection. Since potato stems are much less susceptible to attack by *Rhizoctonia* after green tissue develops following emergence, any practice favoring rapid emergence is useful in disease management. These practices include planting in warm soil above 60° F, warming seed tubers before planting and pre-irrigation of dry soil.
- Cover seed pieces with 4 to 6 inches of soil at planting. If problems with Rhizoctonia canker are anticipated, knock down hills earlier to encourage faster seedling growth.
- Minimize sprout damage during cultivation to limit increased stem infection.
- Harvest tubers in a timely fashion, after vine desiccation and death, to limit the development of sclerotia on tuber surfaces.

Potato and Green Peach Aphids

The San Luis Valley has a comprehensive aphid suppression and monitoring program to control green peach aphid populations.

Potato aphid and brood of young.

Winged and wingless Green peach aphids.

Impact

The primary aphid species found on potatoes in the San Luis Valley are the green peach aphid, *Myzus persicae*, and the potato aphid, *Macrosiphum euphorbiae*.

Aphids transmit virus diseases, notably Potato Virus Y (PVY) and Potato Leafroll Virus (PLRV). The green peach aphid is the most efficient vector of PLRV to potato; potato aphid is less efficient but may be important in some locations and seasons. Many other aphid species transmit PVY. Significant direct injury from aphid feeding rarely occurs, except during extreme outbreaks.

The San Luis Valley has a comprehensive aphid suppression and monitoring program to control green peach aphid populations which occur annually. Populations vary in intensity depending on environmental conditions.

Description and Symptoms

➤ Wingless green peach aphids tend to be pear shaped. They may have variable colors but usually are straw-colored or light-green. Hind cornicles slant so they converge. A key characteristic is tubercles at the base of the antennae.
➤ Potato aphids are more elongate and larger, about 1/6 to 1/8 inch, than the green peach aphid. They often are bright green, but pinkish forms occur. They are similar in general appearance to the English grain aphid.
➤ Both potato and green peach aphids produce winged forms. Winged aphids are most important in spread of viruses to plants since they move readily within and between fields.
➤ Wingless green peach aphids tend to occur on lower, older potato leaves. Potato aphids more commonly colonize the upper part of the potato plant.
➤ During the summer, aphids reproduce asexually (no males) and give live birth to young. Under optimal conditions, a generation may be completed in 10 days.
➤ Several predators and parasites help control aphids. Among the more important insects are lady beetles, damsel bugs, green lacewings, minute pirate, and parasitic wasps.
➤ Green peach aphids overwinter in the egg stage on various *Prunus* species, particularly plum and apricot, in and around towns. It may also be introduced on infested greenhouse plants. Potato aphid overwinters in the San Luis Valley on wild rose.

Integrated Management

- Monitor flights of winged aphids by using yellow traps and follow the weekly San Luis Valley monitoring reports.
- Apply pesticides only when necessary. Use of some insecticides can exacerbate aphid problems, because the control has more effect on natural enemies than on aphids. Insecticides can only provide limited control of aphid transmitted virus diseases. The green peach aphid can be highly resistant to insecticides registered on potatoes. Therefore, choose insecticides carefully for effective control.
- Protect natural predator populations that are important in aphid management.

Leafhoppers

Apply pesticides only to control large infestations which rarely occur. Pesticide application is only economically viable on seed potatoes.

Aster leafhopper.

Impact

The aster or six-spotted leafhopper, *Macrosteles quadrilineatus*, does not injure the plant directly. However, certain phytoplasma-like potato disease agents are transmitted by this insect pest in the San Luis Valley.

The potato leafhopper has not been found in the San Luis Valley. However, the intermountain potato leafhopper, which produces small flecking wounds on leaves, may occur.

Description and Symptoms

➤ Leafhoppers are elongated, wedge-shaped insects, broadest in the head and thoracic regions and tapering along their wings. They are strong fliers and may migrate long distances.
➤ The aster leafhopper's body is dull light green and may appear silvery gray when wings are folded at rest. Six distinct spots occur on the top of the head.
➤ The aster leafhopper is the principal vector of aster yellows or purple top, a disease caused by a bacteria (phytoplasm).
➤ Adults are best sampled by sweep net, and nymphs by examining randomly picked midplant leaves. Nymphs are rarely seen on potatoes in the San Luis Valley.
➤ Several leafhoppers occur in the San Luis Valley, most of which are harmless to potatoes.

Integrated Management

- Scout by taking 100 sweeps across two rows with a net 15 inches in diameter. Check for the presence of adult leafhoppers, which transmit disease organisms. Adults have six dark spots on the head.

- Apply pesticides only to control large infestations which rarely occur. Pesticide application is only economically viable on seed potatoes.

Potato Psyllid

Economically significant outbreaks of potato psyllid are rare in the San Luis Valley and are dependent on large migrations which occur approximately once every five years.

Adult potato psyllid.

Nymph potato psyllid.

Impact

The potato psyllid overwinters in the southern region of North America. Infestations that develop in the San Luis Valley originate each year from winged migrants moving in from overwintering areas along the border of the United States and Mexico.

Economically significant outbreaks of potato psyllid are uncommon in the San Luis Valley and are dependent on large migrations that occur approximately once every five years.

Description and Symptoms

➤ The adult psyllid resembles a tiny cicada and is about 1/8 inch long.
➤ The nymphs are flattened, scalelike and pale yellow-green.
➤ Damage is caused by nymphs that inject a toxin while feeding. The toxin induces a condition known as psyllid yellows. Feeding by adult psyllids has little or no effect on potato yields at any time.
➤ As few as three or four psyllid nymphs per plant can produce psyllid yellows on pre-bloom plants under favorable conditions.
➤ Immature leaves on infested plants turn red or purple and are abnormally erect, with the basal portion cupped.
➤ Older leaves become unusually thick, roll upward and turn yellow. Internodes become shortened.
➤ Affected plants produce aerial tubers and excessive numbers of small, distorted tubers, which may sprout without a dormant period. Skin set and sugars are also affected in tubers from infested plants.
➤ Yield effects occur when plants become infested early in the season.

Integrated Management

- Scout for psyllids before initiating control measures.
- Increase scouting for nymphs seven to 10 days after finding adult populations. Nymphs are most frequently found on plants exhibiting psyllid yellows.
- Scouting for nymphs should concentrate on the lower leaves of early planted potatoes. Examine 50 leaflets randomly selected throughout the field. Potato psyllid can be difficult to scout on potato plants, since populations tend to occur in patches on lower, shaded leaves. Within fields, adult psyllids, but not immature nymphs, are best sampled with a sweep net.
- Apply insecticides whenever nymphs can be easily detected in fields. Treat if more than two to four adults are captured per 100 sweeps and nymphs are detected in fields.
- Protect natural enemy populations by avoiding use of insecticides that adversely affect psyllid predators. Some insecticides (Sevin, Furadan) may aggravate psyllid problems because of effects on their predators.

Lygus Bug and False Chinch Bug

Lygus bug.

Population mass of false chinch bugs.

Impact

Lygus bugs, *Lygus elisus* and *Lygus hesperus*, are general feeders found on most plants and trees. False chinch bugs, *Nysus* spp., may mass in large numbers feeding on a wide range of plant hosts.

Seldom do these insects threaten San Luis Valley potatoes. However, isolated problems may prompt consideration of pesticide application.

Description and Symptoms

Lygus bugs

➤ Immature lygus bugs are smooth, shiny-green insects, similar in size to aphids, which move rapidly when disturbed.

➤ Adult lygus bugs are small, brown to green with piercing-sucking mouthparts and a white "V" on the back.

➤ Lygus bugs inject a toxin during feeding. The toxin kills the area fed upon or causes distorted growth. Damage is most severe on field margins.

➤ Highest lygus bug populations develop in alfalfa. Migration into potatoes occurs when alfalfa fields are cut.

False Chinch Bug

➤ The false chinch bug is less than 1/16 inch long, black with white wings and has a triangular black patch in the middle of the outer margins with red legs.

➤ Adults become active in early spring, feeding on various weeds.

➤ Populations mass at the top of the plant and wilt or kill the leaves.

➤ A wide variety of weed hosts, such as kochias and mustards, are preferred but migration to potatoes may occur when hosts mature.

Integrated Management

- Control populations only when these insects are so abundant as to potentially affect yield. Infestations of false chinch bug, in particular, tend to be patchy in occurrence within a field so spot treatments are most appropriate.

- Common insecticides for potatoes can kill natural enemies as well as insect pests. Protect natural enemies that generally keep these pests under control.

Cutworm, Looper, and Armyworm

Variegated cutworm.

Cabbage looper.

Armyworm.

Impact

Variegated cutworm, *Peridroma saucia*, is the a common cutworm species in the San Luis Valley.

Cabbage loopers, *Trichoplusia ni.*, also are a common pest of vegetables, including lettuce and potato, and flowers.

Armyworms, *Pseudaletia unipuncta*, can occasionally cause severe damage to crops throughout the San Luis Valley. This insect prefers grasses, notably small grains, but will feed on some broadleaf crops such as potatoes after grain matures.

Description and Symptoms

Cutworms

➤ Cutworms feed at night. During the day they can be found under clods of soil or in cracks in the ground near injured plants.

➤ Cutworms have a smooth appearance, three pairs of legs and five pairs of prolegs.

➤ Damage early in the season includes stems cut off at or below ground level. Later, chewed foliage is the most common symptom. Tubers that are exposed on the surface or in cracks in the soil can be chewed by some cutworms.

➤ Cutworms overwinter as immature larvae or eggs in the soil.

Loopers

➤ Loopers have green bodies that taper to the head with a white line on each side and two white lines down the back with three pairs of prolegs.

➤ Irregular cut holes in the leaves is typical looper damage.

Armyworms

➤ Mature larvae are about 1 1/2 inches in length, smooth-bodied, and dark grey to greenish-black in color. They are characterized by five stripes, three on the back and two on the sides, running the length of the body. The stripes on the sides are pale orange with a white outline. The head capsule is remarkable for its honeycomb of black markings.

➤ Dense grass is preferred for egg laying. Armyworm problems in potatoes originate from these sites.

➤ Larvae feed at night and on cloudy days, and hide under crop debris during sunny periods.

➤ Armyworm damage to leaves usually is restricted to field edges bordering small grains.

Integrated Management

- Control weeds to prevent fall egg laying by cutworms.
- Control cutworms, armyworms and loopers only when scouting indicates a potentially damaging infestation.
- Pesticide applications to control armyworms usually can be restricted to field edges.
- Treat infested areas in a specific field using appropriate insecticides when control is necessary.

Checklist for Integrated Weed Management

☑ General

➤ Integrated weed management (IWM) is critical in potato production for high yields and quality.
➤ IWM involves the use of best management practices including cultural, mechanical, biological, and chemical strategies.
➤ Pesticide use poses a potential risk to water quality. However, when pesticides are properly applied and integrated into a management system, the risk is minimized.
➤ In an effective IWM system, the prevention of future infestations is as critical as controlling the immediate problem.
➤ Weed competition can greatly reduce potato yields depending on the weed species and cultivar growth habit.

University of Idaho conducted research in 1991 and 1992 noting the effects on Russet Burbank and Frontier Russet yield and quality from weed competition, row and within-row spacing, and the interaction of these factors. The predominant weeds were redroot pigweed, common lambsquarter, and hairy nightshade. Weedy plots produced less vine and tuber mass, and less total and U.S. No. 1 tuber yields than weed-free plots. Averages of the two years were approximately ***47 percent reduction of total yield and 68 percent reduction of U.S. No. 1 yield.*** *Decreasing row width did not offer a competitive advantage. Decreasing the within-row spacing offered a limited advantage.*

☑ Cultural

➤ Plant high quality, certified seed for vigorous crop growth.
➤ Keep nearby non-crop areas (center pivot sprinkler corners, fence rows, ditches, roadsides, etc.) stabilized to avoid soil erosion and free of weed seed production (established ground cover, mowing weeds, etc.).
➤ Clean all machinery and implements between fields to remove weed seeds, rhizomes and other reproductive plant structures.
➤ Rotate crops to limit increases of weed seed in the soil and perennial weed infestations. Differences in tillage, planting dates, length of growing season, available labeled herbicides, and other cultural factors for different crops can disrupt weed life cycles.
➤ Manage all production factors including within-row and between row spacing to establish a healthy crop population that competes with weeds.
➤ Select fields to be free of weeds that are difficult to control in the upcoming potato crop.
➤ Select well-adapted cultivars for establishing a competitive crop. For example, a small-vined cultivar, which lacks canopy closure can lead to weed problems.

☑ Biological

➤ Use natural enemies (insects, plant pathogens, etc.) to control selected weed species. Typically, biological controls are released on a regional basis. Most emphasis of biological control of weeds is directed at noxious weeds.

☑ Mechanical

➤ Till soil before planting to control existing weeds. Potatoes that emerge before weeds are more competitive for moisture, nutrients and light.
➤ Cultivate weeds in the seedling stage. Properly-timed and managed cultivations and hilling operations can provide complete weed control.
➤ Maintain good soil tilth for vigorous crop growth. Compacted soil limits crop growth and allows for new weed infestations. Chiseling fields in the fall can prevent severe compaction.

☑ Chemical

➤ Anticipate potential weed infestations based on past records, field maps and experience to determine the necessity of herbicide use.
➤ Calibrate sprayer well in advance of herbicide application.
➤ Identify weed species accurately for optimal herbicide selection, application rate and timing of application.
➤ Select herbicides to achieve the best combination of the following factors: weed control, cultivar tolerance, soil residual activity, and leachability. Crop rotations can limit herbicide selection depending on soil persistence and label requirements. Leachability influences the potential of a herbicide to impact water quality.
➤ Time herbicide application based on susceptible weed stages and tolerant crop growth stages which can vary depending on the selected herbicide and cultivar.
➤ Consider application of herbicides at preemergence or early post emergence. Smaller weeds are more easily controlled and less competitive.
➤ Vary selection of herbicides to prevent weed species from becoming herbicide resistant.
➤ Manage the crop for quick canopy closure after herbicide application to reduce subsequent weed establishment or regrowth.
➤ Herbigate only with herbicides labeled for sprinkler application. A chemigation permit is required before herbigating.
➤ Read the herbicide label before application. Note any particular restriction influencing herbicide performance, cultivar tolerance or safety. For example, many cultivars are susceptible to metribuzin.

➤ Read the herbicide label before application. Note any particular restriction influencing herbicide performance or safety.

Pesticide Management for Water Quality

The majority of applied pesticides degrade to harmless products, like carbon dioxide before posing a serious environmental threat. However, small quantities of pesticide may reach groundwater if soil, site and pesticide characteristics favor movement.

When pesticide use is necessary, select the most appropriate product based on the chemical properties of a pesticide. The following properties significantly influence the potential of off-target environmental effects of pesticides:

- **degradation rate** - time necessary to break down a compound to harmless products, like carbon dioxide. The rate is measured as the half life, commonly referred to as **persistence**;
- **adsorptivity** - tendency of a pesticide to be adsorbed by a soil, and measured by the adsorption coefficient;
- **solubility**- tendency of a chemical to dissolve in water, and measured in parts per million (ppm); and,
- **volatility** - tendency of a chemical to become a gas, and measured as vapor pressure.

Persistence, adsorptivity and solubility are important indicating factors of the potential of a pesticide to leach.

Pesticide properties only indicate the probability of leaching (or runoff); soil, site and management factors determine if the chemical actually moves offsite. Coarse textured soils, low-organic matter, shallow water tables and irrigation or single high precipitation events in the San Luis Valley increase the potential for pesticide leaching. However, in most cases, proper management will keep pesticides out of the groundwater.

Evaluate soil, site and pesticide properties to determine what relative hazards to water resources exist from pesticide application. By considering these factors, integrated pest management measures can be selected that are least likely to impact groundwater quality.

Weed Management Chart

WEEDS	TILLAGE			ROTATION				HERBICIDES							
	FALL TILLAGE	SPRING TILLAGE	CULTIVATION	Small Grains	Winter Wheat	Alfalfa	CULTIVAR SELECTION	Eptam (EPTC)	Dual II/Dual (Metolachlor)	Sencor/Lexone (Metribuzin)	Prowl (Pendimethalin)	Treflan (Trifluralin)	Roundup (Glyphosate)	Gramoxone Extra/Cyclone (Paraquat)	Poast (Sethoxydim)
Broadleaf Annuals															
Black Nightshade	X	*	✔	✔	✔	✔	✔	F	G	X	X	X	E	G	X
Cutleaf Nightshade	X	*	✔	✔	✔	✔	✔	G	F	P	P	P	G	G	X
Hairy Nightshade	X	*	✔	✔	✔	✔	✔	G	G	X	X	X	E	E	X
Common Purslane	X	✔	✔	✔	✔	✔	✔	F	E	F	E	E	E	E	X
Kochia	X	✔	✔	✔	✔	✔	✔	X	X	G	X	X	E	E	X
Lambsquarter	X	✔	✔	✔	✔	✔	✔	G	F	E	G	G	E	F	X
Pigweeds	X	*	✔	✔	✔	✔	✔	E	E	E	E	E	E	E	X
Redstem Filaree	X	✔	✔	*	*	✔	✔	X	X	F	X	X	G	F	X
Russian Thistle	X	✔	✔	✔	✔	✔	✔	P	F	G	F	F	E	E	X
Sunflower	X	*	✔	✔	✔	✔	✔	P	P	F	X	X	E	G	X
Annual Grasses															
Barnyardgrass	X	X	✔	*	*	✔	✔	E	E	F	E	E	E	P	E
Foxtails	X	X	✔	*	*	✔	✔	E	E	F	E	E	E	P	E
Volunteer Grains	X	✔	✔	X	X	✔	*	E	F	P	F	F	E	P	G
Wild Oats	X	✔	✔	*	✔	✔	*	E	F	P	F	F	E	P	G
Witch Grass	X	X	✔	*	✔	✔	✔	E	E	F	E	E	E	P	E
Perennials															
Canada Thistle	X	X	X	✔	✔	*	X	X	X	S	X	X	F	S	X
Field Bindweed	X	X	X	✔	✔	*	X	X	X	X	X	X	F	S	X
Quackgrass	X	X	X	*	*	*	X	S	X	S	X	X	G	S	G
Water Quality Concerns															
Leachability	-	-	-	-	-	-	-	M	M	H	L	L	L	L	L
Persistence	-	-	-	-	-	-	-	L	M	M	L	M	L	L	L

Excellent (90-100 percent control)	E	High	H
Good (75-90 percent control)	G	Medium	M
Fair (50-75 percent control)	F	Low	L
Poor (0-50 percent control)	P	Suitable	✔
No useful control/not labelled	X	Inconsistent (varies)	*
Suppression (reduces early season growth, but no control)	S	Not applicable	-

Note: This chart is a guideline to selected weed management techniques. Good weed management is critical for success. For example, herbicide performance is dependent on proper use as indicated on the product label. Also, not all techniques are applicable to all conditions. For example, excessive tillage may result in high soil erosion. An integrated approach of varied techniques is key to weed control.

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Colorado State University Cooperative Extension offices are local resources for additional fact sheets and publications on agriculture, natural resources, consumer and family education, 4H/youth education, and community resource development.