Crop Profile for Potatoes in Colorado

Prepared: September, 2000
Revised: September, 2003

Solanum tuberosum (Solanaceae)

General Production Information

	1997	1998	1999	2000	2001
Acres in Colorado:	84,800	83,500	84,900	83,900	73,200
Percent U.S. Acreage:	6.2%	5.8%	6.1%	6.0%	5.9%
National Ranking:	3rd	5th	4th	5th	6th
Per Acre Value (Net):	$1,530.00	$1579.20	$1457.25	$1,165.15	$2,964.41
Value of Production in Colorado:	$129,744,000	$130,700,000	$122,926,000	$97,756,000	$216,995,000

Data from 1997-2001 Colorado and National Agricultural Statistics Services

Description of Crop

An annual root crop. The tubers are either sold fresh after harvesting, stored or sold in the form of mashed potato flakes, fries or chips.

Cropping System

Early potatoes (summer potatoes) are planted in March and harvested in July or August. Late potatoes (winter potatoes) are planted in April or May and harvested between September and November (usually September 15 - October 12). A technique called hilling is employed when planting potatoes: mounds of soil are formed around the plants to avoid exposing tubers to light and to make harvesting easier. Hilling also helps control some diseases as well as annual broadleaf and grass weeds.

The Crop Profile/PMSP database, including this document, is supported by USDA NIFA.

Optimal soil and ambient temperatures for planting are 50 F and 70 F, respectively. A common row width is 34", and 15,000 seed potatoes are planted per acre. Minimum and conventional tillages are used.

Uniformly applied water will ensure proper tuber development. Sprinkler irrigation and some flood irrigation is used seasonally supplying 14 - 17" of water to each plant. Each potato cultivar has a specific evapotranspiration rate which should be used when calculating irrigation water needed.

Potatoes are usually part of a five year crop rotation which includes corn, onions, barley, and beans. In the San Luis Valley, the predominant rotation is a two year crop rotation of potatoes and malting barley.

One to two weeks before harvest, potato vines are removed by mechanical choppers or a chemical desiccant. Tubers are harvested mechanically. Bruising is a common problem during harvest. For post-harvest storage, the potatoes are cooled to 50 F for two weeks, then held at 40 F with 96% humidity.

Other Pesticides-

Pesticide: **maleic hydrazide** (Clean Crop Maleic Hydrazide HC)

- Use: Growth Regulator (control sprouting)
- Recommended rate: 40 fl oz ai/A (7 pt product/A)
- Use Data:
  - 1992= rate used- 2.55 lb ai/A
    2% of total acres treated
  - 1997= rate used- 1.40 lb ai/A
    13% of total acres treated
  - 2001= rate used- 1.60 lb ai/A
    5% of total acres treated

Pesticide: **metam sodium** (Vapam)

- Use: General Soil Fumigant/Injection
- Target Pests: Controls soilborne diseases and supression of various weeds
- Recommended rate: 2150 fl oz ai/A (40 gal product/A)
- Use Data:
  - 1997= rate used- 121.92 lb ai/A
    30% of total acres treated
  - 2001= rate used- 340.80 lb ai/A
    20% of total acres treated

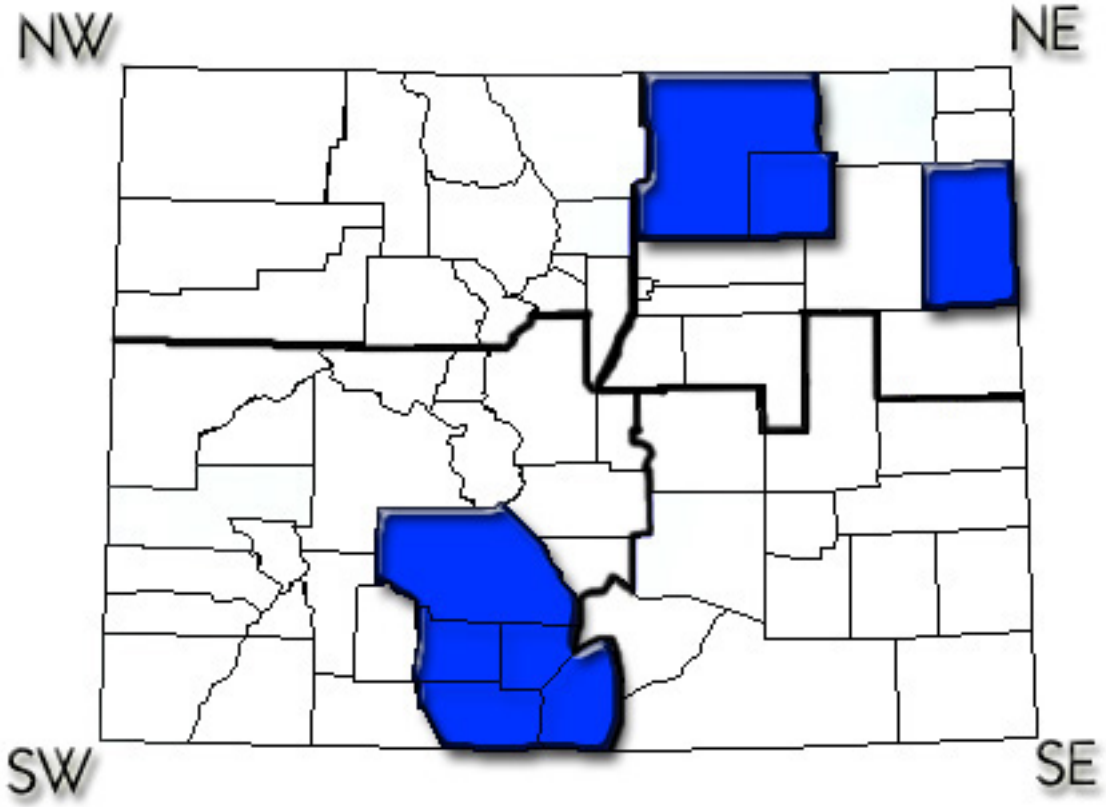
Pesticide: **sulfuric acid** (Sulfuric Acid Potato Vine Dessicant)

- Use: Vine Dessicant

- Recommended rate: Both 93% and 98% sulfuric acid is sold by Kennecott which is the registered company in Colorado which supplies sulfuric acid
- Use Data:

1992= rate used- 305.9 lb ai/A
27% of total acres treated
1997= rate used- 340.8 lb ai/A
27% of total acres treated
2001= rate used- 382.0 lb ai/A
34% of total acres treated

Location of Production



Northeast

Morgan, Weld, Yuma

Southwest

Alamosa, Conejos, Costilla, Rio Grande, Saguache

Note: Shaded boxes indicate counties where the crop is grown. Regions have been delineated by Interstates I-70 and I-25.

Insects

Key Insects

Armyworm, *Pseudaletia unipuncta*

Armyworms occur in eastern Colorado and in the San Luis Valley. Mature larvae are about 1.5" long, smooth-bodied, and dark gray to greenish-black. They are characterized by five stripes running the length of the body, three on the back and two on the sides. Stripes on the back vary in color, whereas the stripes on the sides are pale orange with a white outline. The head capsule is remarkable for its "honeycomb" of black markings. The armyworm is unable to survive Colorado winters. Instead, armyworm moths migrate into Colorado in early summer. They lay their eggs in rows or clusters on the lower leaves of various grass crops. Dense grassy vegetation is preferred for oviposition. Newly hatched larvae move with a looping (inchworm) action. Larvae feed at night and on cloudy days, and hide under crop debris during sunny periods. One or more generations may occur each year. Armyworms feed on leaves, kernels, and beards of small grain heads. Their most obvious damage to small grains is by clipping the heads.

Chinch Bugs, *Blissus leucopterus*

Chinch bugs is about 0.16" long and black with opaque wings that may be as long as the body. Each wing bears a distinctive, triangular black mark. The egg is flattened at one end and has three to five minute projections. The egg gradually changes in color from pale yellow to red before hatching. Wingless nymphs are smaller than, but similar in shape to the adult. The head and thorax are brown, the eyes are dark red, and the abdomen is pale yellow or light red with a black tip. Chinch bugs pierce the plant with their four-jointed beak and suck out the plant sap. Feeding prevents normal growth and results in dwarfing, lodging and yield reduction. Severe infestations during early development cause wilting and premature plant death. Most injury is caused by the six nymphal instars. Chinch bugs overwinter as adults in various protected areas, particularly among weeds and grasses near fields. Adults emerge in the spring and deposit eggs singly behind the leaf sheath or in the soil at the base of crop plants. In a few days, the eggs hatch and the nymphs begin feeding on all parts of the host plant from the roots to the uppermost leaves. There are 2 - 3 generations per year. Crop rotation, especially with legumes, is an effective cultural control practice. Chinch bug feeding is also deterred by a vigorously growing crop. Therefore, timely seeding, ample fertilization, and thorough weed control help prevent chinch bug damage.

Cutworms

Cutworms, such as variegated cutworm (*Peridroma saucia*), are commonly found on potatoes. Variegated cutworms are dark gray with a light stripe on the side, and small, yellow-orange spots on their abdomens. They are a climbing species and feed mainly at night, though daytime feedings are common. They do not feed on plant roots, but cut plants off at or above the soil line; they may also feed on young foliage in the center of the crown. Cutworm feeding on tubers can cause crop injury. Several cutworm species attack a wide range of plants. Most feeding occurs at night. The larvae hide in the soil near the surface during the day. Full grown cutworm larvae are 1.5 - 2" long. Coloration will vary among species, but all tend to be stout-bodied caterpillars with four sets of prolegs. They curl into a ball

when disturbed. Seedlings are girdled at the soil line, and stands may be significantly reduced in some cases. Life cycles vary among the different species. Several generations may occur each year, but overwintering larvae and the first generation in the spring are the most damaging. Larvae overwinter in the soil, especially in grassy or weedy situations. Fall and spring cultivation will help reduce populations of overwintering larvae. Insecticides such as esfenvalerate, methyl parathion, or permethrin are effective if applied in a timely manner and directed at the soil around the base of the crop plants.

Green Peach Aphid, *Myzus persicae*

The green peach aphid is a small teardrop shaped aphid when wingless, less than 0.125" long. Their antennae reach about to the body end of the cornicles. Most green peach aphid colonies have light green individuals, but some, especially later in the summer, may consist of pink or pale orange individuals. Winged green peach aphids have brown heads and thoraxes, dark green abdomens with brown patches. Green peach aphid colonies are found on the lower leaves of the crop. The aphid is introduced each spring from greenhouse stock. Effects of green peach aphid injury include bud blight, leaf curling, discoloration or chlorosis, gradual wilting, and plant death. Green peach aphids are vectors of potato leaf roll virus and potato virus Y (mosaic).

Potato Aphid, *Macrosiphum euphorbiae*

Potato aphids are slightly larger than green peach aphids; the body is slimmer, with a tail-like appendage at the end of the abdomen. Adults have antennae that are longer than their body. The adult potato aphid is clear green to pink and glossy. Both winged and wingless aphids can be found on the underside of foliage, and on the lower leaves within the canopy, feeding on the plant. Potato aphids are also known to vector various plant diseases, two of which are of economic concern in Colorado - potato leaf roll virus and potato virus Y (also referred to as potato mosaic virus).

Wireworms, Family: *Elateridae*

Wireworms are the larval stage of a family of beetles commonly called click beetles. Adults are brown or black and elongate, tapering toward each end but more so towards the rear. Earlier larval stages are very small and white, later stages have a characteristic hard shell appearance and a shiny yellow to reddish-brown color with six slender legs. Mature larvae range from 0.5 - 1" in length, depending on the species. Wireworms usually overwinter in the adult stage. Females deposit eggs in the soil. When the eggs hatch, larvae feed on tubers. In potatoes, wireworms usually stay in the top 2 - 3" of soil. During the winter, they move as far down as 2' deep. Larvae require 2 - 5 years for maturation and most damage is caused by older larvae. Fully developed larvae pupate in the soil. Emergent adults remain in the soil until the following spring. Wireworms feed on seed pieces in the spring, occasionally damaging young shoots. The damaged seed pieces secondarily become infected with bacteria or fungi, and plants grow weakly or fail to emerge. Later in the summer, wireworms bore into tubers, leaving straight round holes that usually heal over and do not become infected with rotting microorganisms. As plants mature, wireworms girdle plant stems. Wireworm cultural controls include rotating to non-host crops and tilling

fallowed fields. If stand growth is significantly reduced early in the season, replanting may be an option.

Additional Insects

Aphids, Family: *Aphididae*

Aphid life cycles vary with species. Aphids of any type can reduce yield through feeding. Aphids are small, soft-bodied insects found singly or in clusters on stems or on the undersides of leaves. Aphids overwinter as eggs and adults. The tiny aphids hatch in the spring, mature rapidly and give birth - without mating - to living young. Mature aphids fly to cultivated crops during the spring and summer where they form new colonies. Only females are produced during the summer and with their rapid rate of reproduction, it is possible for large numbers to develop in a short period of time. They may be a problem throughout the season. As cool weather approaches in the fall, both males and females are produced. They mate and lay eggs that overwinter. Aphids attack the leaves, blossoms, pods, and other parts of their host plants, sucking plant juices through their tiny needle-like beaks. Heavily infested plants become stunted and do not produce normal crops.

Cabbage Looper, *Trichoplusia ni*

Cabbage loopers are commonly found on potatoes. Adult cabbage loopers are night flying insects with a wide range of host plants, including: collard greens, broccoli, cauliflower, potato, spinach, lettuce, parsley, tomato and cucumber. Adults lay single, small, round greenish white eggs on host plant leaves, which hatch several days later. Larvae are green with white stripes, are the most destructive stage in the looper life cycle, and they feed on the undersides of leaves. Most of the feeding damage can be seen between the leaf veins. This feeding continues for 2 - 4 weeks, at which point the loopers pupate. Adults emerge from the pupae 10 days to 2 weeks later and begin the cycle again. In some areas, loopers can have 3 generations per year. Foliar feeding rarely reduces yields.

Colorado Potato Beetle, *Leptinotarsa decemlineata*

Colorado potato beetle adults have stout, striped, oval bodies. The stripes are slim and alternate between yellow-orange and black on the wing covers. Eggs are laid in clusters and are bright orange. There are four larval stages of development that can be easily distinguished from one another by head width and body size. As the larvae mature, their color changes from brick red to pale orange. Adults mate and lay eggs in clusters on the underside of potato leaves. Most eggs are laid in mid-June, but some are laid sooner if weather and temperature permits. Eggs hatch in 4 - 16 days. There is usually one generation each year, though there may be two. In mid-August, adults burrow into the soil 6 - 12" deep to overwinter. Both adult and immature Colorado potato beetles feed on leaf edges which often results in complete leaf destruction. Complete defoliation is possible if the beetles go unmanaged, newly emerged stems may be clipped by the beetles. Yield can decline by 50% or more. However, depending on the growth stage, potato plants can withstand some defoliation without affecting yield.

Flea Beetles: Potato Flea Beetle, Three-spotted Flea Beetle, Pale Striped Flea Beetle and Tuber Flea Beetle, *Epitrix cucumeris, Disconycha triangularis, Systena blanda and E. tuberis*

Adult beetles are typically small, often shiny, and have large rear legs that allow them to jump like a flea when disturbed. Flea beetles overwinter in the adult stage hidden under leaves, dirt clods, or in other protected sites. They become active during warm days in mid spring but may straggle out over several weeks. Many flea beetles are strong fliers and seek out emerging host plants that they locate by chemical clues the plants produce. Adults feed for several weeks. Soon thereafter, females intersperse feeding with egg laying. They lay eggs in soil cracks around the base of the plants. The minute, worm-like larvae then move to feed on small roots and root hairs. The larval stage is completed in about a month. The insects pupate and emerge from the soil as adults. There may be a second generation during the summer and, with a few species, a third generation. Flea beetles produce a characteristic injury known as "shot-holing" in which the adults chew many small holes or pits in the leaves, making them look as if a fine buckshot has damaged them. Young plants and seedlings are particularly susceptible. Growth may be seriously retarded and plants even killed. Leaf feeding also damages plant appearance, which can impact the marketability of leafy vegetable crops. Although flea beetles are common, injuries are often insignificant to plant health. On established plants, 10 - 20% or more of the leaf area must be destroyed before there is any negative yield effects.

Potato Leafhoppers, *Empoasca fabae* (Harris)

The potato leafhopper can be a serious problem in potatoes early in the season. It overwinters in the Gulf Coast area, and its migration into this region usually occurs in too low of numbers and too late in the season to cause serious damage. Potato leafhoppers are wedge shaped and green, with six white spots on their prothorax. Potato leafhoppers inject a toxin during leaf feeding that damages the plant and results in leaf discoloration and stunting. The threshold for insecticide treatment such as methyl parathion is one leafhopper per leaf.

Potato/Tomato Psyllid, *Paratrioza cockerelii*

The adult is an active, small clear-winged insect with prominent eyes and well developed legs. Adults are light green at first, but turn black with white markings within three days of molting. Wings are roof-like over the body at rest. Nymphs are flat, scale-like insects, pale green, with a ring of short hairs completely circling the margin of the bodies. They are typically found on the upper half of the plant. Psyllids feed by sucking sap from plants, and injecting a toxin in the process. Potato psyllids excrete a granular material that resembles salt or sugar, and is called "lerps". Examining leaves for lerps will indicate whether or not the psyllid is present in the field. Three to four generations can develop during the growing season. Psyllid saliva contains a toxin which causes an adverse reaction in potato called "psyllid yellows". Damaged potato leaves curl, turn yellow and often cease growth. Affected potatoes produce many small, unmarketable tubers with rough skins. Infected tubers also tend to sprout prematurely. If the attack on potato plants occurs before tuber set, a likely result is the formation of numerous tubers on each stolon. An attack after tubers are partially developed usually results in greatly

retarded growth and irregularly shaped potatoes. These tubers will not produce a strong plant if used for seed. Other host plants of the potato/tomato psyllid are tomatoes, peppers and eggplant.

Key Insect Management Strategies

Cultural Controls

Lady bugs are a successful biological insect control for aphids primarily, but lady bugs also feed on mites, small insects, and insect eggs.

Insecticides -

Pesticide: **azinphos-methyl** (Guthion)

- Target Pests: Colorado potato beetle
- Recommended rate: 6.0-8.8 oz ai/A (0.75-1.1 lb product/A)
- Comments: Preharvest Interval 7 days

Pesticide: **Bacillus thuringiensis** (DiPel 4L)

- Target Pests: Colorado potato beetle, Cutworms, Loopers
- Recommended rate: 0.14 -3.30 oz ai/A (0.5-2.0 lb product/A)

Pesticide: **Bacillus thuringiensis** (Javelin WG)

- Target Pests: Colorado potato beetle, Cutworms, Loopers
- Recommended rate: 0.14-1.80 oz ai/A (0.12-1.50 lb product/A)

Pesticide: **carbaryl** (Sevin XLR Plus)

- Target Pests: Colorado potato beetle
- Recommended rate: 14-28 fl oz ai/A (1-2 qt product/A)

Pesticide: **carbaryl** (Sevin 80S)

- Target Pests: Colorado potato beetle
- Recommended rate: 16-32 oz ai/A (1.25-2.5 lb product/A)

Pesticide: **carbaryl** (Sevin 50W)

- Target Pests: Colorado potato beetle
- Recommended rate: 16-32 oz ai/A (2-4 lb product/A)

Pesticide: **carbofuran** (Furadan 4F)

- Target Pests: Colorado Potato beetle
- Recommended rate: 7-14 fl oz ai/A (1-2 pt product/A)
- Comments: Preharvest interval 14 days
- Use Data:
  1997= rate used- 1.5 lb ai/A
  10% of total acres treated
  2001= rate used- 1.5 lb ai/A
  8% of total acres treated

Pesticide: **cryolite** (Kryocide 96W)

- Target Pests: Colorado Potato Beetle
- Recommended rate: 153.6-184.3 oz ai/A (10-12 lb product/A)

Pesticide: **disulfoton** (Di-Syston 8E)

- Target Pests: Aphids
- Recommended rate: 6.8-13.6 fl oz ai/A (0.5-1 pt product/A)
- Comments: Preharvest Interval 30 days

Pesticide: **disulfoton** (Di-Syston 15G)

- Target Pests: Aphids
- Recommended rate: 2.3-3.5 oz ai/1000 row ft (15-23 oz product/1000 row ft)
- Comments: Preharvest Interval 75 days
- Use Data:
  1997= rate used- 0.87 lb ai/A
  4% of total acres treated
  2001= rate used- 0.07 lb ai/A
  1% of total acres treated

Pesticide: **endosulfan** (Thiodan 3EC)

- Target Pests: Potato psyllid, Aphids, Colorado potato beetle
- Recommended rate: 5.3-9.9 fl oz ai/A (0.7-1.3 qt product/A)
- Comments: Preharvest Interval 1 day
- Use Data:

1992= rate used- 0.63 lb ai/A
23% of total acres treated
1997= rate used- 0.84 lb ai/A
11% of total acres treated
2001= rate used- 0.75 lb ai/A
13% of total acres treated

Pesticide: **esfenvalerate** (Asana XL)

- Target Pests: Potato psyllid, Colorado potato beetle, Cutworms, Loopers
- Recommended rate: 0.48-0.80 fl oz ai/A (5.8-9.6 fl oz product/A)
- Comments: Preharvest Interval 7 days
- Use Data:
  1992= rate used- 0.03 lb ai/A
  26% of total acres treated
  1997= rate used- 0.03 lb ai/A
  50% of total acres treated
  2001= rate used- 0.03 lb ai/A
  45% of total acres treated

Pesticide: **ethoprop** (Mocap 10G)

- Target Pests: Nematodes, wireworms, symphylans
- Recommended rate:
  Banded:
  3.4 oz ai/1000 row ft (2.1 lb product/1000 row feet)
  Broadcast:
  64-192 oz ai/A (40 to 120 lb product/A)
- Use Data:
  1992= rate used- 4.35 lb ai/A
  19% of total acres treated
  1997= rate used- 4.08 lb ai/A
  10% of total acres treated
  2001= rate used- 0.10 lb ai/A
  1% of total acres treated

Pesticide: **imidacloprid** (Admire 2F)

- Target Pests: Potato psyllid, aphids, Colorado potato beetle
- Recommended rate: 0.19-0.27 fl oz ai/1000 row ft (0.9-1.3 fl oz product/1000 row ft)

Pesticide: **imidacloprid** (Provado 1.6F)

- Target Pests: Potato psyllid, aphids, Colorado potato beetle
- Recommended rate: 0.65 fl oz ai/A (3.75 fl oz product/A)
- Comments: Preharvest Interval 7 days

Pesticide: **imidacloprid + cyfluthrin** (Leverage 2.7)

- Target Pests: Potato psyllid, aphids, Colorado potato beetle
- Recommended rate: imidacloprid: 0.65 fl oz ai/A; cyfluthrin: 0.45 fl oz ai/A (3.75 fl oz product/A)
- Comments: Preharvest Interval 7 days
- Use Data:
  2001= rate used- 0.17 lb ai/A
  18% of total acres treated

Pesticide: **methamidophos** (Monitor 4)

- Target Pests: Potato psyllid, aphids, Colorado Potato beetle
- Recommended rate: 9.6-12.8 fl oz ai/A (1.5-2 pt product/A)
- Comments: Preharvest Interval 14 days
- Use Data:
  1992= rate used- 0.72 lb ai/A
  18% of total acres treated
  1997= rate used- 1.34 lb ai/A
  7% of total acres treated
  2001= rate used- 0.40 lb ai/A
  1% of total acres treated

Pesticide: **methyl parathion** (Penncap-M)

- Target Pests: Grasshoppers, Cutworms, Flea Beetles, Leafhopper, Tarnished Plant Bug, Colorado Potato Beetle
- Recommended rate: 6.7-20.2 fl oz ai/A (2-6 pt product/A)
- Comments: Preharvest Interval is 5 days
- Use Data:
  1992= rate used- 0.73 lb ai/A
  1% of total acres treated
  2001= rate used- 0.80 lb ai/A
  2% of total acres treated

Pesticide: **permethrin** (Ambush 25W)

- Target Pests: Potato psyllid, Colorado potato beetle, Cutworms, Loopers
- Recommended rate: 1.0-3.2 fl oz ai/A (4-12.8 fl oz product/A)

Pesticide: **permethrin** (Pounce 3.2E)

- Target Pests: Potato psyllid, Colorado potato beetle, Cutworms, Loopers
- Recommended rate: 1.6-3.2 oz ai/A (6.4-12.8 oz product/A)
- Comments: Preharvest Interval 7 days
- Use Data:
  1992= rate used- 0.10 lb ai/A
  13% of total acres treated
  1997= rate used- 0.19 lb ai/A
  29% of total acres treated
  2001= rate used- 0.14 lb ai/A
  33% of total acres treated

Pesticide: **phorate** (Thimet 20-G)

- Target Pests: Potato psyllid, Wireworms, Aphids
- Recommended rate: 2.3-3.5 oz ai/1000 row ft (*11.3-17.3 oz product/1000 row ft)
- Comments: *Applied at planting; Preharvest Interval 75 days
- Use Data:
  1992= rate used- 2.47 lb ai/A
  1% of total acres treated
  1997= rate used- 2.50 lb ai/A
  10% of total acres treated
  2001= rate used- 2.47 lb ai/A
  1% of total acres treated

Key Weeds

Barnyardgrass, *Echinochloa crusgalli*

Barnyardgrass, a member of the Grass family, is an annual that prefers wet sites. It is not usually a problem in well-drained cultivated fields but can grow heavily around irrigation pipe leaks and other wet spots in the field. It is a vigorous, warm season annual grass reaching 1 - 5' in height. Many stem bases are reddish to dark purple. Leaf blades are flat, broad, smooth, and without a ligule or auricle at the junction of sheath and blade. Seed are the only source of reproduction. It flourishes in warm conditions.

Black Nightshade, *Solanum ptycanthum*

Black Nightshade, a member of the Nightshade family, is an annual that grows 6 - 24" tall with glabrous, appressed-hairy stems. Black nightshade is a Colorado noxious weed and varies greatly in form and color. Seed leaves of black nightshade are elongate-oval and pointed; the first true leaves are spade-shaped with smooth edges. Lower leaf surfaces are often purple. Berries turn from green to black when mature and the calyx covers only a small part of the fruit surface. Petioles, stems and leaves have some hairs but are not densely hairy or sticky. Leaves are ovate, smooth to wavy-edged and have a tapered tip. Flowers are white to pale blue, 0.25 - 0.4" wide borne in clusters. Flowering season is from May to October. Seed are the only source of reproduction.

Green Foxtail, *Setaria viridis*

Green foxtail is a member of the Grass family and shorter than other foxtails. Green foxtail is on the Colorado noxious weed list. Other characteristics distinguishing it from other foxtail species include: roughened leaf sheaths, lack of hairs, and smaller seed than other foxtails. Seed are broadly oval, green and found in spike-like panicles that are 1 - 4" long. Green foxtail is native to Eurasia, but common throughout most of North America. Green foxtail is responsible for reductions in yields, increased seed cleaning costs, and expensive control measures. Flowering and seed production are in July, August and September.

Hairy Nightshade, *Solanum sarrachoides*

Hairy nightshade, a member of the Nightshade family, is an annual. Hairy nightshade is on the Colorado noxious weed list. Leaves have wavy edges, prominent veins and numerous fine, short hairs, especially along the underside of the main vein. Berries are green or yellowish brown when mature, never black. The calyx covers the entire upper surface of the fruit. The pedicels, like stems and leaves, are usually hairy. Mature plants reach about 2' in height.

Kochia, *Kochia scoparia*

Kochia, a member of the Goosefoot family, is native of Eurasia. It is an annual, reproducing solely by seed. Kochia is on the Colorado noxious weed list. Flowering season is from July to October. Stems are erect, round, slender, pale green, branched, and 1 - 6' tall. Leaves are narrow, bright green, hairy, numerous and are attached directly to the stem. Upper leaves are more narrow than lower leaves. Flowers are inconspicuous in the upper leaf axils. Seed are about 0.063" long, wedge-shaped, dull brown, and slightly ribbed. Kochia can be found throughout Colorado up to 8,500' in elevation. It has become a major problem on roadsides, waste areas, and non-cultivated fields. In the fall, plants become red, later turning brown and breaking away from the root, causing them to tumble over the ground scattering large amounts of seed. Many kochia populations in Colorado are resistant to sulfonylurea, imidazilinone, triazine and benzoic acid herbicides, representing three very different modes of action.

Redstem Filaree, *Erodium cicutarium*

Redstem Filaree, a member of the Geranium family, is a winter annual or biennial with stems that are 1" - 2' long, spreading or erect, generally originating from a rosette. Redstem filaree is on the Colorado noxious weed list. Leaves are divided into narrow feather-like lobed or toothed segments. Both leaves and stems are hairy. Flowers are purplish-pink and generally borne in clusters of 2 or more. The fruit is 5 lobed and long-beaked, with each lobe splitting away at maturity.

Redroot Pigweed, *Amaranthus retroflexus*

Redroot Pigweed, a member of the Amaranth family, was introduced from Europe and tropical America. It is an annual that reproduces by seed. The stem is light green, erect, stout, tough, rough-hairy, branched and 1 - 6" tall. The taproot is long, red and somewhat fleshy. Leaves are alternate with the lower ones ovate, about 3 - 6" long, pointed at the tip, dull green, rough-hairy, with prominent ribs and veins. Upper leaves are smaller, narrower, and more lance-shaped. Flowers are small, green, and densely crowded in large, bristly, simple, or branched, terminal or axillary clusters. Redroot pigweed grows in cultivated fields, pastures, roadsides, and waste places in Colorado in elevations up to 8,500'. It is one of the most prominent, non-native annual plants found in cultivated fields in eastern Colorado. Redroot pigweed is ALS herbicide resistant.

Sunflower, *Helianthus annuus*

Sunflower, a member of the Sunflower family, is a native weed. It is an annual, 1 - 10' tall. Stems are erect, simple to branched and rough. Leaves are alternate, simple, rough, and hairy. Ray flowers are yellow to orange-yellow and disk flowers are brown. Flowering is from July to September. Seed are the only source of reproduction.

Wild Oats, *Avena fatua*

Wild Oats, a member of the Grass family, is an annual weed, 1- 4' tall with erect, hollow stems. Although oats are grown in Colorado as a crop, the wild species is very different and is on the Colorado noxious weed list. Leaf blades are 0.125 - 0.625" wide with open sheaths and membranous ligules. Seedling leaves twist counterclockwise. The inflorescence is an open panicle, 4 - 18" long, drooping, spikelets contain 2 - 3 florets which disarticulate above the glumes. Seed are yellow to black, narrowly oval, 0.25 - 0.5" long. This species is distinguished from domestic oats by the twisted awn which bends at right angles and a horseshoe shaped scar at it seed base.

Wild Proso Millet, *Panicum miliaceum*

Wild Proso Millet, a member of the Grass family, is an annual, reproducing by seed. Although proso millet is grown in Colorado as a crop, the wild species is very different and is on the Colorado noxious weed list. Seed germination is in the spring and throughout the summer when soil temperatures reach 68 F. Seed germinate and emerge from the soil as deep as 4" below the surface, but are equally able to germinate closer to the soil surface. Once in the soil, wild proso millet seed can remain viable for five or

more years. Wild proso millet plants range in height from 1' in dry areas to 4 - 6' on irrigated sites. Stems of wild proso millet have abundant hairs located at right angles to the stem. As plants grow larger, they lodge and put down additional roots wherever stem joints touch the ground. Plants can begin flowering in July and continue throughout the summer. The inflorescence produced by wild proso millet is large and bushy. Seed matures in late August through September. Once mature, it readily shatters when the plant is disturbed. Plants can produce 400 - 12,000 seed per square foot, depending upon the degree of plant competition.

Additional Weeds

Canada Thistle, *Cirsium arvense*

Canada thistle, a member of the Sunflower family, was introduced from Europe. It is a creeping perennial which reproduces by seed and fleshy, horizontal roots. Canada thistle is on the Colorado noxious weed list as well as marked as one of the top ten most widespread weeds causing the greatest economic impact to the State of Colorado. Stems are erect, hollow, smooth and slightly hairy, 1 - 5' tall, simple, and branched at the top. The leaves are set close on the stem, slightly clasping, and dark green. Leaf shape varies widely from oblong to lance-shaped. There are numerous sharp spines on the outer edges of the leaves, branches and main stem. The flowers are small and compact, about 0.75" or less in diameter, and light pink to rose-purple in color, occasionally white. The seed are oblong, flattened, dark brown, and approximately 0.125" long. Canada thistle emerges in April or May in most parts of Colorado. Infestations are found in cultivated fields, riparian areas, pastures, rangeland, forests, lawns, gardens, roadsides, and waste areas. Because of its seeding habits, vigorous growth, and extensive underground root system, control or eradication is difficult. It is distributed across Colorado in elevations ranging from 4,000 - 9,500'.

Common Mallow, *Malva neglecta*

Common mallow, a member of the Mallow family, is a winter annual or biennial with stems that are low and spreading. The branches are erect from 2 - 20" long. Leaves are long-petioled, rounded with a heart shaped base. They are 0.75 - 3.5" in diameter and have 5 - 7 inconspicuous lobes. Flower petals, ranging from white to pale lavender, are fused and about twice the length of the calyx. Fruits consist of a circle of rounded, one-seeded lobes that separate at maturity, exposing the seed. Reproduction is solely by seed.

Russian Thistle, *Salsola iberica* and *S. collina*

Russian thistle, a member of the Goosefoot family, was introduced from Russia. It is an annual and reproduces by seed. It is on the Colorado noxious weed list. It is a round, bushy, branched plant growing 1 - 3.5' high. The branches are slender, succulent when young, and woody when mature. The first leaves to develop are alternate, dark green, soft, slender, and 1 - 2.5" long. These senesce early and new leaves form which are alternate, short, stiff, spiny, and not over 0.5" long, with two sharp-pointed bracts at the

base. The flowers are small, inconspicuous, green-white or pink, and are usually solitary in the leaf axils. Seed are conical and 0.063" in diameter. Russian thistle grows in dry plains, cultivated fields, roadsides, and waste areas, primarily in grain-growing areas of the state. At maturity, the plant breaks off at the base. Its round shape allows it to tumble, scattering seed for long distances. It is widespread over Colorado in elevations up to 8,500'.

Key Weed Management Strategies

Herbicides-

Pesticide: **diquat** (Reglone)

- Target Pests: Vine dessicant
- Recommended rate: 1.0-2.0 pt product/A (5.9-11.9 fl oz ai/A)
- Use Data:
  - 1992= rate used- 0.25 lb ai/A
    10% of total acres treated
  - 1997= rate used- 0.25 lb ai/A
    16% of total acres treated
  - 2001= rate used- 0.25 lb ai/A
    23% of total acres treated

Pesticide: **endothall** (Desicate II)

- Target Pests: Vine dessicant
- Recommended rate: 1.5-2 qt product/A (25.4-33.9 fl oz ai/A)

Pesticide: **EPTC** (Eptam 7E; Eptam 10G)

- Target Pests: Volunteer barley
- Recommended rate: Preplant: 3.5-7.0 pt product/A; Lay-By: 3.5-4.5 pt product/A [Preplant: (49.2-98.3 fl oz ai/A); Lay-By: (49.2-63.2 fl oz ai/A)]
- Comments: Maximum of 14 pints/A in one season
- Use Data:
  - 1992= rate used- 4.56 lb ai/A
    37% of total acres treated
  - 1997= rate used- 3.00 lb ai/A
    85% of total acres treated
  - 2001= rate used- 3.00 lb ai/A
    65% of total acres treated

Pesticide: **glyphosate** (many)

- Target Pests: All weedy species
- Recommended rate: 6-12 pt product/A (48-96 fl oz ai/A)
- Comments: Preplant application
- Use Data:
    1997= rate used- 0.70 lb ai/A
        4% of total acres treated
    2001= rate used- 0.70 lb ai/A
        3% of total acres treated

Pesticide: **metribuzin** (Sencor 4F)

- Target Pests: Foxtails, Pigweed, Kochia, Leafy spurge, Russian thistle
- Recommended rate: 0.5-2.0 pt product/A (3.3-13.1 fl oz ai/A)
- Use Data:
    1992= rate used- 0.27 lb ai/A 1997= rate used- 0.40 lb ai/A
        70% of total acres treated
    2001= rate used- 0.25 lb ai/A
        71% of total acres treated

Pesticide: **pendimethalin** (Prowl 3.3EC)

- Target Pests: Pigweed, Kochia
- Recommended rate: 1.2-3.6 pt product/A (7.2-21.5 fl oz ai/A)
- Use Data:
    1992= rate used- 1.2 lb ai/A
        1% of total acres treated
    1997= rate used- 2.0 lb ai/A
        4% of total acres treated
    2001= rate used- 1.5 lb ai/A
        12% of total acres treated

Pesticide: **rimsulfuron** (Matrix)

- Target Pests: Barnyardgrass, Foxtails, Pigweed, Kochia, Mustard
- Recommended rate: 1.0-1.5 oz product/A (0.25-0.38 oz ai/A)
- Use Data:
    1992= rate used- 0.03 lb ai/A
        21% of total acres treated

Pesticide: **S-metolachlor** (Dual II Magnum)

- Target Pests: Pigweed, Kochia, Volunteer barley
- Recommended rate: 1.00-1.33 pt product/A (13.2-17.5 fl oz ai/A)
- Comments: **S-metolachlor** was **metolachlor**
- Use Data:
    1992= rate used- 1.95 lb ai/A
        18% of total acres treated
    1997= rate used- 1.90 lb ai/A
        10% of total acres treated
    2001= rate used- 1.00 lb ai/A
        41% of total acres treated

Pesticide: **trifluralin** (Treflan 4L)

- Target Pests: Barnyardgrass, Foxtails, Kochia, Lambsquarters, Pigweed, Russian thistle
- Recommended rate: 1.0-2.0 pt product/A (6.9-13.8 fl oz ai/A)
- Use Data:
    1992= rate used- 0.53 lb ai/A
        1% of total acres treated

Critical Pest Management Issues

Scab can no longer be considered of minor importance. It usually occurs in locations with high soil moisture and low soil temperature. There are no above ground symptoms, but powdery scab can survive in the soil for up to six years, and can survive in the digestive tracts of animals. Control includes rotation with non-Solanaceous crops. In fields where powdery scab has been observed, increase the rotation time out of potatoes.

Late blight continues to be a concern; new fungicides and cultural controls will be needed to manage this problem.

Red stem filaree in the San Luis Valley as well as sunflower and late-season hairy nightshade are weeds that are not being adequately managed in potatoes in Colorado.

ALS herbicide resistance can be selected for very quickly, even after two applications. More commonly, population pressure due to consecutive applications or continuous production of the same crop year after year using only ALS herbicides selects for resistance. In many situations, resistance is selected for along right-of-ways and then resistant biotypes move into agricultural fields. It is important to rotate herbicide modes of action to prevent future cases of herbicide resistance.

Weeds, diseases, and insects can all develop resistance over time to pesticides. When the same pesticide

is used consecutively over a period of time, the target pest can become resistant to that pesticide and render the pesticide obsolete.

Diseases

Key Diseases

Blackleg of Potato, *Erwinia carotovora* pv. *carotovora* and *E. carotovora* pv. *atroseptica*

This potato disease is caused by two different forms of a bacterium, *Erwinia carotovora* pv. *carotovora* and *E. carotovora* pv. *atroseptica*. The first is more prevalent in warmer areas and the latter in cooler areas, but they can occur together. Blackleg appears as a soft or slimy black lesion extending from the seed piece through the lower stem. Foliage appears stiff, erect and chlorotic. As the disease develops, wilting occurs in individual leaflets and subsequently throughout the entire stem. Plants eventually collapse. Aerial blackleg, infection of petioles and stems independent of decaying seed, may occur when upper portions of the plant come into contact with soil or decaying plant matter. Infected tubers exhibit a wet soft rot, often starting from the stem end. Rotted tubers may have a foul smell due to the secondary colonization of anaerobic bacteria. The bacteria survive in cull piles, the soil and infected tubers. They are then spread through seed tubers, irrigation water or machinery. Disease is favored by cool, wet conditions early on followed by high temperatures during growth and maturity. Management practices include the use of certified seed, seed piece treatment with bactericides such as TOPS MZ (thiophanate methyl + mancozeb), irrigation management, and balanced fertility.

Early Blight, *Alternaria solani*

Early Blight can cause serious losses in the field as well as in storage. Most general protectant fungicides such as azoxystrobin, chlorothalonil, copper hydroxide, mefenoxam, metiram, and triphenyltin hydroxide used for late blight will also control early blight. Fungicides applied prior to the appearance of the first early blight lesions will provide no additional control. Proper irrigation and fertility will reduce losses due to early blight by reducing plant stress. Foliar disease severity is often not related to the degree of tuber decay. Minimizing tuber bruising and injury during harvest is an effective management tool as well as providing optimal conditions for wound healing in order to reduce tuber decay.

Internal Heat Necrosis of Potato

This condition is caused by sub-oxidation of rapidly respiring internal tissues during active tuber growth and high temperatures. Symptoms appear as light tan to black necrotic flecks clustered off-center in the flesh. These spots are firm and may be concentrated towards the apical end. Symptoms are more severe when the season is hot and dry and potatoes are grown in light soils. Necrosis is more severe in tubers

near the soil surface. This condition may be mistaken for fungal and viral diseases or phosphorus deficiency.

Late Blight, *Phytophthora infestans*

Late Blight overwinters in infected potato tubers. The main source for initial inoculum is infected seed potatoes and infected potatoes discarded in cull piles. Fungicides (azoxystrobin, chlorothalonil, copper, cymoxanil, dimethomorph, mefenoxam, mancozeb, metiram, propamocarb hydrochloride, and triphenyltin hydroxide) are an important component of a comprehensive late blight management program. An application schedule based on environmental parameters can effectively be used to time the initial foliar fungicide application. Fungicides cannot be used alone for effective control of late blight, but must be used as one tool in an integrated management strategy. Fungicides must be used as protectants against late blight. Attempting to use any fungicide to eradicate late blight after it is well established promotes the selection and spread of new resistance. Under most situations, thorough coverage of fungicide must be in place prior to secondary disease spread. Management of foliar disease may indirectly protect tubers from infection and reduce storage loss. The vines should be dead for at least 24 hours prior to harvesting the tubers. This will reduce problems with late blight.

Additional Diseases

Silver Scurf, *Helminthosporium solani*

Silver scurf is caused by a fungus, *Helminthosporium solani*, which is spread by infected seed pieces and potato debris in soil. The disease can worsen in storage, particularly if humidity is above 90%. Symptoms include small, light brown circular spots that tend to grow together and cover large areas of tubers. Sometimes scurf is an olive color from the fungal spores. When lesions are wet, they take on a silvery color that gives the disease its name. The disease frequently is mixed with black dot disease on tubers. Recommended control measures are as follows: early harvest of tubers, manipulation of storage conditions, use of uninfected seed, control of volunteer plants, and crop rotation.

Viruses

Viruses that can infect potatoes include Potato Virus X (PVX), Potato Virus Y (PVY), Potato Virus S (PVS), Potato Virus A (PVA), and Potato Virus M (PVM). There are approximately forty different virus or viroid (nucleic material without protien coat) particles which can infect potato. These viruses are transmitted mechanically and by insects. One potato plant can be infected with one or more viruses at the same time. Research shows that PVX in combination with PVS reduces yields 10 - 25%. Viruses normally do not cause symptoms in most popular potato cultivars, hence the designation "latent." Severe strains may cause a mild mottle or slightly distort leaves. Some cultivars are more sensitive to one or more of the viruses and exhibit easily observed symptoms. Specific symptoms may occur when two or more of the viruses infect the plant at the same time. Viruses are difficult to control through pesticide

use. Control of vectors in the field will help reduce spread from plant to plant, but it is essential to use a certified seed program with virus-free seed.

Key Disease Management Strategies

Cultural Controls

Accurate timing and application of irrigation water, timely cultivation and crop rotations minimize potato pest problems. The vines should be dead for at least 24 hours prior to harvesting the tubers. This will reduce problems with late blight.

Nematicides-

Pesticide: **carbofuran** (Furadan 4F)

- Target Pests: Nematodes-see comments
- Recommended rate: 42 fl oz ai/A (3 qt product/A)
- Comments: Preharvest interval 14 days, **24c registration** for nematodes in CO
- Use Data:
  - 1997= rate used- 1.5 lb ai/A
    10% of total acres treated
  - 2001= rate used- 1.5 lb ai/A
    8% of total acres treated

Pesticide: **dichloropropene** (Telone II)

- Target Pests: Plant parasitic nematodes
- Recommended rate: 140 fl oz ai/A (12 gal product/A)
- Use Data:
  - 2001= rate used- 197.0 lb ai/A
    4.2% of total acres treated

Pesticide: **dichloropropene + chloropicrin** (Telone C-17)

- Target Pests: Nematodes, wireworms, symphylans
- Recommended rate:
  - Mineral soil:
    dichloropropene: 1082-1714 fl oz ai/A, chloropicrin: 228-361 fl oz ai/A (10.8-17.1 gal product/A)
  - Cyst-forming nematodes:
    21.6 gal product/A (dichloropropene: 2165 fl oz ai/A, chloropicrin: 456 fl oz ai/A)]

Muck or peat soil:
dichloropropene: 2746-3006 fl oz ai/A, chloropicrin: 579-634 fl oz ai/A (27.4-30.0 gal product/A broadcast)

Pesticide: **metam sodium** (Vapam)

- Target Pests: Nematodes
- Recommended rate: 2150-5376 fl oz ai/A (40-100 gal product/A)
- Use Data:
  1997= rate used- 121.92 lb ai/A
  30% of total acres treated
  2001= rate used- 120.80 lb ai/A
  20% of total acres treated

Pesticide: **oxamyl** (Vydate)

- Target Pests: Plant parasitic nematodes
- Recommended rate: 30.7-61.4 fl oz ai/A (1-2 gal product/A)
- Use Data:
  2001= rate used- 1.89 lb ai/A
  10% of total acres treated

Fungicides-

Pesticide: **azoxystrobin** (Quadris)

- Target Pests: Late blight, Early blight, Silver scurf
- Recommended rate: 0.10-0.25 fl oz ai/A (6.2-15.4 fl oz product/A)
- Use Data:
  2001= rate used- 0.25 lb ai/A
  47% of total acres treated

Pesticide: **chlorothalonil** (Bravo Zn)

- Target Pests: Late blight, Early blight, Botrytis vine rot
- Recommended rate: 15.4-19.7 fl oz ai/A (1.0 pt, then 1.5-2.2 pt product/A)

Pesticide: **chlorothalonil** (Bravo Ultrex)

- Target Pests: Late blight, Early blight, botrytis, vine rot
- Recommended rate: 21.1-27.7 oz ai/A (0.7 lb, then 0.9-1.4 lb product/A)

- Use Data:
    1992= rate used- 0.97 lb ai/A
        34% of total acres treated
    1997= rate used- 1.40 lb ai/A
        43% of total acres treated
    2001= rate used- 1.40 lb ai/A
        42% of total acres treated

Pesticide: **chlorothalonil + copper oxychloride** (Echo 720)

- Target Pests: Late blight, Early blight, botrytis, vine rot
- Recommended rate: 180 oz ai/A (0.75 pt, then 1.5-2.2 pt product/A)
- Usage for **copper** based products:
- Use Data:
    1992= rate used- 0.67 lb ai/A
        20% of total acres treated
    1997= rate used- 1.80 lb ai/A
        11% of total acres treated
    2001= rate used- 1.80 lb ai/A
        18% of total acres treated
- Comments: Includes all the following copper pesticides

Pesticide: **copper hydroxide** (Champ Formula 2)

- Target Pests: Late blight and early blight
- Recommended rate: 3.9-15.9 fl oz ai/A (0.66-2.66 pt product/A)

Pesticide: **copper hydroxide** (Kocide 101)

- Target Pests: Late blight and early blight
- Recommended rate: 12.3-18.5 oz ai/A (1-1.5 lb product/A)
- Comments: Higher rate for when disease is severe

Pesticide: **copper sulfate** (Basicop)

- Target Pests: Late blight and early blight
- Recommended rate: 25.4-50.9 oz ai/A (3-6 lb product/A)

Pesticide: **copper oxide** (Nordox 75WG)

- Target Pests: Late blight
- Recommended rate: 16.8-33.6 oz ai/A (1.25-2.50 lb product/A)

- Target Pests: Early blight
- Recommended rate: 8.8-53.7 oz ai/A (0.66-4.0 lb product/A)

Pesticide: **cymoxanil** (Curzate 60 DF)

- Target Pests: Late blight
- Recommended rate: 2.0 oz ai/A (3.33 oz product/A)

Pesticide: **dimethomorph + mancozeb** (Acrobat MZ)

- Target Pests: Late blight
- Recommended rate: dimethomorph: 3.2 oz ai/A; mancozeb: 21.6 oz ai/A (2.25 lb product/A)
- Use Data:
  1997= rate used- 0.30 lb ai/A
  4% of total acres treated
  2001= rate used- 0.30 lb ai/A
  1% of total acres treated

Pesticide: **mancozeb** (Dithane M-45)

- Seed Treatment
  - Target Pests:Fusarium dry rot, Scab, Rhizoctonia, Silver scurf
  - Recommended rate: 6.4-25.6 oz ai/A (0.5-2.0 lb product/A)
- Foliar Treatment
  - Target Pests: Early blight, Late blight
  - Recommended rate: 6.4-25.6 oz ai/A (0.5-2.0 lb product/A)

Pesticide: **mancozeb** (Penncozeb 75 DF)

- Seed Treatment
  - Target Pests: Fusarium dry rot, Scab, Rhizoctonia, Silver scurf
  - Recommended rate: 15 oz ai/ 50 gal of water (1.25 lb product/50 gal of water)
- Foliar Treatment
  - Target Pests: Early blight, Late blight
  - Recommended rate: 12-24 oz ai/A (1.0-2.0 lb product/A)
- Use Data:
  1992= rate used- 1.12 lb ai/A
  40% of total acres treated
  1997= rate used- 1.70 lb ai/A
  11% of total acres treated
  2001= rate used- 1.70 lb ai/A
  18% of total acres treated

Pesticide: **maneb** (Maneb 75 DF)

- Seed Treatment
  - Target Pests: Fusarium dry rot
  - Recommended rate: 11.2 oz ai/10 gal of water (1 lb/10 gal of water)
- Foliar Treatment
  - Target Pests: Early blight, Late blight
  - Recommended rate: 18-24 oz ai/A (1.5-2.0 lb product/A)

Pesticide: **maneb** (Maneb 80W)

- Seed Treatment
  - Target Pests: Fusarium dry rot
  - Recommended rate: 12.8 oz ai/A (1 lb/10 gal of water)
- Foliar Treatment
  - Target Pests: Early blight, Late blight
  - Recommended rate: 19.2-25.6 oz ai/A (1.5-2.0 lb product/A)
- Use Data:

  1992= rate used- 1.7 lb ai/A
  14% of total acres treated
  1997= rate used- 2.0 lb ai/A
  16% of total acres treated
  2001= rate used- 2.0 lb ai/A
  19% of total acres treated

Pesticide: **mefenoxam** (Ridomil Gold)

- Target Pests: Late blight, Early blight, Pink rot, and Pythium Leak
- Recommended rate: 0.20 oz ai/1,000 row ft (0.42 oz product/1,000 row ft)
- Use Data:

  1992= rate used- 0.16 lb ai/A
  1% of total acres treated
  1997= rate used- 1.40 lb ai/A
  5% of total acres treated
  2001= rate used- 1.40 lb ai/A
  14% of total acres treated

Pesticide: **mefenoxam + chlorothalonil** (Ridomil Gold Bravo)

- Target Pests: Late blight, Early blight, Pythium Leak
- Recommended rate: mefenoxam: 1.4 oz ai/A; chlorothalonil: 23.0 oz ai/A (2.0 lb product/A)

Pesticide: **mefenoxam + copper hydroxide** (Ridomil Gold Copper)

- Target Pests: Pythium Leak
- Recommended rate: mefenoxam: 1.5 oz ai/A; copper hydroxide: 19.2 oz ai/A (2.0 lb product/A)

Pesticide: **mefenoxam + mancozeb** (Ridomil Gold MZ)

- Target Pests: Late blight, Early blight, Pink rot, and Pythium Leak
- Recommended rate: mefenoxam: 1.5 oz ai/A; mancozeb: 20.5 oz ai/A (2.5 lb product/A)

Pesticide: **metiram** (Polyram 80 DF)

- Foliar Treatment
    - Target Pests: Late blight, early blight
    - Recommended rate: 19.2-25.6 oz ai/A (1.5-2 lb product/A)

Pesticide: **metiram** (Potato Seed Treater PS)

- Seed Treatment
- Target Pests: Late blight, early blight
- Recommended rate: rate per 100 lb seed, 1.3-1.9 oz ai (1.0-1.5 lb/100 lb seed)

Pesticide: **propamocarb hydrochloride** (Previcur Flex)

- Target Pests: Late blight, Tuber blight
- Recommended rate: 7.4-22.3 fl oz ai/A (0.7-2.1 pt product/A)
- Comments: Preharvest Interval 14 days

Pesticide: **streptomycin-sulfate** (Agri-mycin 17)

- Target Pests: Tuber soft rot, Blackleg
- Recommended rate: 0.9 oz ai/100 gal of water (100 ppm, 4 oz product per 100 gal of water)

Pesticide: **sulfur** (Liquid Sulfur Six)

- Target Pests: Powdery Mildew
- Recommended rate: 25-33 fl oz ai/8 gal of water (3.0-4.0 pt product/8 gal of water)
- Use Data:

    1992= rate used- 1.7 lb ai/A
    18% of total acres treated
    1997= rate used- 2.2 lb ai/A

25% of total acres treated
2001= rate used- 2.2 lb ai/A
20% of total acres treated

Pesticide: **thiabendazole** (Mertect 340F)

- Target Pests: Fusarium Tuber rot
- Recommended rate: 0.18 fl oz ai/1 gal water (Dipping: 0.42 fl oz/1 gal water)
- Comments: Tubers are dipped for 20 sec

Pesticide: **thiophanate methyl** (TOPS 2.5D)

- Target Pests: Fusarium (dry rot), Rhizoctonia
- Recommended rate: 0.4 oz ai/100 lb seed (1.0 lb/100 lb of cut seed)

Pesticide: **thiophanate methyl** (TOPS 5)

- Target Pests: Fusarium (dry rot), Rhizoctonia
- Recommended rate: 0.4 oz ai/100 lb seed (0.5 lb/100 lb of cut seed)
- Comments: Seed treatment

Pesticide: **thiophanate methyl + mancozeb** (TOPS MZ)

- Target Pests: Fusarium (dry rot), Rhizoctonia, Silver scurf, Late blight, Blackleg
- Recommended rate: thiophanate methyl: 0.3-0.4 oz ai/A; mancozeb: 0.7-1.0 oz ai/A (0.75-1.0 lb/100 lb of cut seed)
- Comments: Seed treatment

Pesticide: **triphenyltin hydroxide** (Super Tin 80WP)

- Target Pests: Late blight, early blight
- Recommended rate: 2-3 oz ai/A (2.5-3.75 oz product/A)
- Comments: Preharvest Interval 21 days
- Use Data:
  1992= rate used- 0.23 lb ai/A
  20% of total acres treated
  1997= rate used- 0.38 lb ai/A
  50% of total acres treated
  2001= rate used- 0.38 lb ai/A
  39% of total acres treated

Nematodes

In general, above ground symptoms are not readily noticeable. However symptoms from severe nematode damage appear as stunted growth, chlorosis, and wilting during periods of high temperature and moisture stress. These symptoms can be similar to those induced by nutrient deficiencies. Root symptoms of nematode infection vary with the kind of nematode.

Pink Rot, *Phytophthora erythroseptica*

A complex of Phytophthora species cause this disease. Pink Rot is the causal agent identified. The disease can be found in the field before harvest and is characterized by rotted tuber tissues that turn pink after exposure to air for 20 - 30 minutes. Another important diagnostic trait for pink rot is that the rot will usually appear to start from the stem end of the tuber and will then progress through the tuber in a very uniform manner, often with a nearly straight line between the healthy and the diseased portions of the tuber. Pure pink rot is not a slimy soft rot, but infected tissues are easily, and often invaded by soft rot bacteria which will cause this symptom. In a tuber that is infected with the pink rot fungus alone, the rotted tissues will retain some structure and firmness but not nearly as much as the healthy portions of the tuber. The texture of the infected tuber tissue is much like that of a boiled potato. Another feature of pink rot is the characteristic smell of ammonia that is given off by pink rot infected tubers. This odor can frequently be detected where potatoes are stored prior to the development of visual symptoms. Pink rot infections are usually associated with wet conditions, low spots in the field, near wheel tracks or simply in over-watered areas. Infections usually occur in the soil prior to harvest through the lenticels, eyes or through the stolons of the tubers. This disease can rot a tuber quite rapidly, usually within just a couple of weeks. Infection can occur through wounds made during harvest and handling. Usually pink rot involves only the tuber but symptoms of the above-ground portions of the plant sometimes occur. Infected plants may wilt, with the leaves becoming chlorotic and eventually drying up and falling off. Occasionally, aerial tubers will form as well. Most all potato varieties are susceptible to pink rot. Fungicides are effective controls if applied properly, if not applied properly resistance to particular fungicides has been known to occur. Strains of Phytophthora are resistant to metalaxyl-based compounds (Ridomil). Use of protectant sprays can avoid formation of fungal spores. Mefenoxam (Ridomil Gold) used in conjunction with other fungicides (Ridomil Gold Bravo) is the recommendation for managing this disease.

Pythium Leak, *Pythium* spp.

This disease is caused by *Pythium* spp. Pythium species identified as causal agents in potato are *P. ultimum* var. *ultimum*, *P. aphanidermatum* and *P. deliense*. These fungi are soil-borne. Leak is characterized by a rot that starts from an infection site on the surface of the tuber and generally rots out the entire central portion of the tuber while leaving the portion of the tube from the vascular ring out to the skin of the tuber intact. This results in a condition that is often described as "shell rot." The rotted tissues are brown to black in color and may have cavities within them. The texture of the rotted tissues is

not a slimy soft rot but is much more watery with a slightly granular appearance. When a diseased tuber is squeezed a clear fluid can be expressed from the tuber. This is the origination of the name "watery wound rot," another name for leak. Like pink rot, the diseased tubers can be easily invaded by soft rot bacteria. The net result with both diseases are wet spots in storage that frequently 'sink' as a result of rotting tubers being crushed from the weight of tubers above them. *Pythium* invades the tuber wounds that occur during harvest, especially when tuber pulp temperatures are high (>68 F). For this reason, leak is usually more prevalent in years characterized by unseasonably warm temperatures during harvest. These fungi require wounding to infect the tuber. Due to this requirement, Pythium will not be found in the field before harvest like pink rot. *Pythium* can be responsible for seed-piece decay in cut seed if conditions are warm and wet immediately after planting. There are no vine symptoms associated with Pythium leak. Fungicides are effective controls if applied properly, if not applied properly resistance to particular fungicides has been known to occur. Strains of Pythium are resistant to metalaxyl-based compounds (Ridomil). Use of protectant sprays can avoid formation of fungal spores. Mefenoxam (Ridomil Gold) used in conjunction with other fungicides (Ridomil Gold Bravo) is the recommendation for managing this disease.

Ring Rot of Potato, *Clavibacter michiganensis* subsp. *sepedonicus*

Ring rot of potato is a serious threat to the potato seed industry where there is a zero tolerance in seed stocks. In the field, symptoms appear as yellowing of leaflets, which curl up at the edges. This drooping of a few terminal leaves progresses to a more general wilt, collapse and death. Foliar symptoms of bacterial ring rot generally appear at mid-season or later. Yellow areas develop on leaf margins or between veins and later turn brown, giving the leaves a burned appearance. Plants with advanced symptoms show vascular discoloration and milky, viscous bacteria may be forced from cut stems. In tubers, symptoms may occur before harvest or in storage. Rot begins as a brown necrosis in the vascular ring and progresses to the surface. Cracks may appear on surfaces of tubers, which are frequently nothing more than hollow shells. However, these symptoms do not occur until late in the season if at all. When infected plants are cut at the base and squeezed, a stringy exudate oozes from the vascular bundles. Symptoms in tubers begin at the stem end and progress throughout the vascular ring. This appears as a cheesy, crumbly rot. The bacterium overwinters in tubers and as dried slime on tools and equipment. Ring rot is controlled effectively through use of certified seed.

Scab, *Streptomyces scabies*, *S. acidiscabies* and *S. turgidiscabies*

Scab in potatoes is caused by *Streptomyces* spp., a filamentous bacterium that lives in soil and on diseased tubers. Neutral or alkaline soils favor scab development. Russet cultivars are generally less affected than smooth-skinned cultivars and should be grown where scab has been severe. Symptoms including corky lesions appear on the tuber's surface. Lesions may be small and superficial or consist of deep pits. Controls recommended are resistant varieties and pathogen-free clean seed, rotation excluding alternate hosts, maintaining an acidic soil and avoiding soil moisture stress.

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