

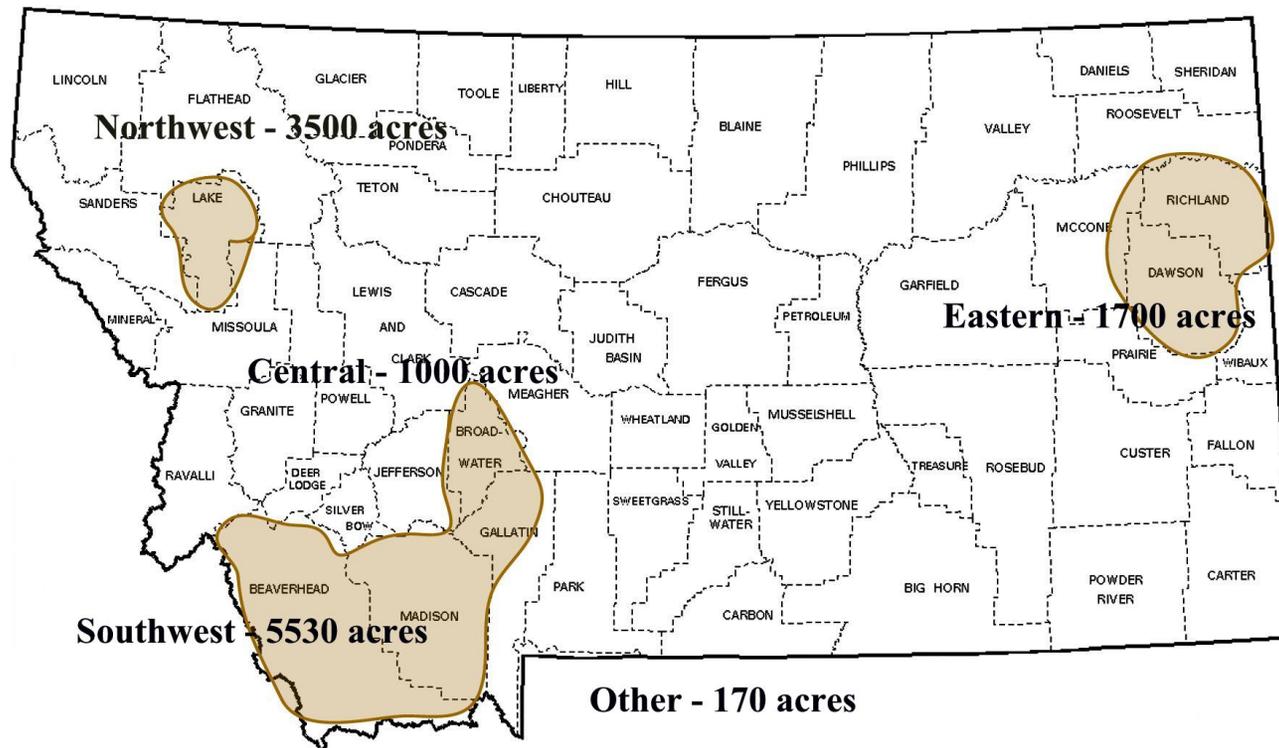
Crop Profile for Potato in Montana

Revised: June, 2002

General Production Information

Acres in Montana	=	12,700
National Production:	=	0.7% (2000 Data)
National Ranking:	=	17 th (2000 Data)
Yearly production of seed potatoes:		
Acres planted	=	11,000
Acres harvested	=	10,900
Yield per cwt	=	305,000
Value of production	=	\$3,325,000 per cwt
Production costs	=	\$1000 to \$2000 per acre.
Commercial production	=	1700 acres

Production Regions in Montana



Seed Potato Production

- Major production areas for seed potatoes are located in a belt from the southwestern area of Montana north to the northwestern area of Montana.
- The Northwest region has 33% of the potato acreage and 30% of the production. The largest producing county is Lake County.
- The North Central region has 7% of the potato acreage and 6% of the production.
- The Central region has 8% of the potato acreage and 9% of the production. The largest producing county is Broadwater.
- The Southwest region has 51% of the potato acreage and 54% of the production. The largest producing counties are Beaverhead, Gallatin, and Madison.
- Other areas of the state have 1% of the potato acreage and 1% of the production.

Commercial Production

- Richland & Dawson Counties, in eastern Montana raise approximately 1700 acres of Russet potatoes that are sold for French fries in North Dakota. Russets are planted in late April to early May for early processing and harvested late August to early September. Russet Burbank are planted for storage and later processing and harvested late September to October. Diseases of primary concern are early and late blight. The Colorado potato beetle is the only insect of noted importance and this area does not have any specific weed problems due to cultural practices.

History of Potatoes

Cultivated by the first peoples of the high Andes of western South America for at least 7,000 years, the potato was introduced to Europe from Peru, Chile, and Columbia by Spanish and English explorers in the mid-1500s. While first disdained as a food source, once its nutritional value was realized, the potato spread rapidly. Today, it is the fourth most important food crop in the world, following rice, wheat, and maize (corn to us). Still, it is technically a monoculture: hundreds of varieties, but all of them a single species and susceptible to the same pests and diseases. All cultivated white potatoes are technically a single species: *Solanum tuberosum* of the plant family *Solanaceae*. Due to the natural genetic diversity of the potato, breeders have developed cultivars that will grow in most areas of the world with the exception of extreme temperature and humidity ranges.

Nutritional Value

An average potato supplies:

3 grams of fiber or about 10% of a persons daily fiber requirement

4 mg Vitamin C or 22 percent of the RDA

6 grams iron 7 to 10 percent of the RDA

4 grams of protein

15 – 19 percent of the RDA for Vitamin B-6

750 milligrams of potassium or about 21% of the recommended daily allowance

no fat

100 calories

Cultural Practices

Description of Crop

The potato (*Solanum tuberosum*) is a member of the nightshade (*Solanaceae*) family. All green parts of the plant, including the green parts of the tubers are poisonous due to an alkaloid called solanine. The plant has multiple stems and pinnate leaves that grows about one foot. Below the surface of the ground, tubers form on the ends of the roots. While the potato is a perennial, commercially grown potatoes are planted each year from carefully selected, certified seed.

Potatoes require 100 frost free days, with a minimum air temperature of 50° and a minimum soil temperature of 38° – 40° degrees. Potatoes grow well in a variety of soils from acidic to alkaline and sandy to clayey. Soils in Montana are primarily well drained loess to sandy silty clay loams. With adequate moisture and the warm days and cool evenings, quality potato growth can be anticipated. Montana experiences long, cold winters with deep frost levels killing the majority of pests affecting potatoes.

Cropping System

Seed potatoes are planted in May and harvested in September and October. Optimal soil and ambient temperatures for planting are 50° F and 70° F, respectively. A common row width is 36" with row spacing for Russets 10" – 13" and Red and Yukon Gold 7" – 9". Planting depth is approximately 2" – 4". Conventional tillage is used and potato crops are predominated irrigated with sprinkler systems.

Producers use a long crop rotation of 3 to 6 years. Crop rotation in western Montana is with small grains or alfalfa. In eastern Montana, crop rotation is with dry beans or sugar beets. Cultivation is used for weed control. The resultant aeration, and proper seed depth, prevent greening of the tubers. Sprinkler irrigation is used on the majority of crops. Irrigation allows for precise management and application of water, nutrients, and crop enhancement materials. No thinning occurs in seed potatoes.

Fertilizers, herbicides, insecticides, and fungicides optimize production and control insects and disease. Half of the fertilizer is typically broadcast before planting and the balance applied as a side dressing after planting. Additional application of nitrogen and potash through irrigation is based on tissue analysis. Application of insecticides typically occur at planting and again at six weeks to sixty days after emergence. Regular application of pesticides throughout the growing season control aphids and the Colorado potato beetle. The majority of herbicides are applied before planting.

One to two weeks before harvest, mechanical choppers or a chemical desiccant removes potato vines. The vines should be dead for at least 24 hours before harvesting the tubers reducing problems with late blight. Tubers are harvested mechanically. Bruising is a major problem during harvest. For post-harvest storage, the potatoes are cooled to 50° F for two weeks, then held at 38° - 40°F with 96% humidity to reduce shrinkage.

Seed Certification Program

Montana has a reputation for producing some of the "cleanest" certified seed potatoes in the country. Montana producers sell certified seed potatoes throughout the United States, for production of commercial crops.

The seed potato program in Montana is one of limited generations. Hills, clones, and clone increase are all steps in the development of the seed stocks. Pre-testing of all nuclear stock for diseases in the laboratory is required. Montana certified seed potatoes have only two grade standards. The blue tag is equivalent of the U.S. No. 1 grade standard and the red tag is equivalent of the U.S. No. 2 grade standard with exceptions for both noted in Rules and Regulations, Section 11, 4.12.3503.

Mandatory testing for PVX and PVY is required for all meristem, nuclear, G1, and G2 seed. In 1996, Montana's State Department of Agriculture began enforcing quarantine on importation of seed potato transplants and tomato transplants unless the plants were certified as free of the late potato blight fungus.

Montana seed growers produce forty-three cultivars with Russet potatoes being the dominant species. The following table provides a list of seed potatoes varieties and acres planted in 2000.

Variety	Acres	Variety	Acres	Variety	Acres
A79543-R	0.2	Caribe	365.03	Red LaSoda	20.62
A7961-1	0.3	Cherry Red	0.03	Red Pontiac	2.23
A82360-7	9.2	Gem Russet	54.307	Russet Burbank	5129.47
A84118-3	41.93	Idaho Rose	0.13	Russet Norkotah	2070.37
A88338-1	2.77	King Edward	0.013	Russet Norkotah (3)	13.283
A90586-11	1.017	Laratte	0.29	Russet Norkotah (8)	6.05
NDO2786-10	2	Liberty Russet	42	Russian Banana	0.25
RMB161	20.28	NewLeaf Plus Russet Burbank	2.95	Sangre	17.953
All Blue	1.023	NewLeaf Y Shepody	6	Sephody	186.2
All Red	0.403	Norland	11.61	Umatilla	1525.54
Amey (B-9922-11)	0.02	Norland, "Dark Red"	37.341	White Rose	16.2
Amisk	152.5	Norland, "Red"	0.05	Yellow Finn	10.15
Atlantic	0.3	Purple Peruvian	0.25	Yukon Gold	40.867
Bannock	0.23	Ranger Russet	1170.4		0.032
Cal White	72.47	Red Gold	0.04		

Insect Pests

Green Peach Aphid (*Myzus persicae*)(GPA)

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 colored individuals, but some, especially later in the summer, may consist of pink or pale orange colored individuals. Winged green peach aphids have brown heads and thoraxes, with a dark green abdomen with brown patches. GPA colonies tend to be found on the lower leaves of the crop plants causing blighting of the buds, curling leaves, discoloration or chlorosis, gradual wilts, and even plant death. The GPA is a carrier of a number of viruses that seriously impact the potato crop. The two viruses that cause the greatest concern are the potato leaf roll virus (PLRV) and the potato virus Y.

Cultural control methods are an integral part of reducing populations of GPA. Control of nightshade, mustard, and sunflowers and other host species with insecticides and herbicides will limit the ability of the aphids to survive during the winter reducing the opportunity to infest potato fields the following year. It is important to maintain full season aphid control to reduce the possibility of PLRV. Reducing aphid populations to tolerable levels requires a combination of control measures using cultural practices and several insecticides with different modes of action. The GPA is resistant to many of the common insecticides.

Potato Aphid (*Macrosiphum cuphurbiae*) (PA)

Potato aphids are slightly larger than green peach aphid; with a slimmer body, a tail-like projection at the end of the abdomen, and antennae longer than the body. The adult potato aphid is a clear green to pink and glossy. Both winged and wingless aphids feed on the underside of foliage, lower down in the canopy. The potato aphid carries several diseases but like the GPA the most serious are the PLRV and potato virus Y. Insecticides used to control the GPA will control the potato aphid.

Colorado Potato Beetle (*Leptinotarsa decemlineata*) (CPB)

The Colorado potato beetle (CPB) is the second most significant pest for potato producers. CPB adults have stout, oval bodies with slim stripes that alternate between yellow-orange and black on the wing covers. The color of the larvae changes from a brick red to a pale orange as they mature. The CPB invades potato fields as an adult laying 300 to 500 eggs over a 4 week period in mid-June, sooner if conditions are conducive. Clusters of the bright orange eggs are laid on the underside of the potato leaves hatching in 4 – 16 days. Both adults and larvae feed heavily on the edge of the leaves often resulting in complete destruction of the leaf. In addition, they may clip off newly emerged stems. The larvae are more damaging to the potato than the adult CPB. Potato plants can withstand some defoliation without affecting yielding, dependent upon the growth stage, but a complete defoliation is possible if the beetles go unmanaged, and yields may be reduced by 50% or more. There is usually one generation each year, but two may occur. In mid-August, adults burrow into the soil 6 - 12" deep to overwinter.

Control of CPB is primarily with soil applied insecticides. Natural enemies are not sufficiently abundant to contain populations. While synthetic insecticides remain the most effective means for its control, resistance by the CPB to all classes of insecticides has been documented in many U.S. potato-producing regions. Resistance has the greatest potential to eliminate insecticides as useful tools in CPB management.

Cutworms (*Agrotis ipsilon*) (*Peridroma saucia*)(CW)

Several species attack a wide range of plants. Most feeding occurs at night. Cutworm larvae are found just below the surface of the soil or under the dense foliage of the potato plant. They feed primarily on foliage but will chew into exposed tubers or cut the stems of small plants. The cutworm larva matures at 1 – 2" in length. Coloration will vary among species, but all tend to be stout-bodied caterpillars with four sets of prolegs and often curl into a "C" shape when threatened. 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. Systemic insecticides control cutworms during the initial growing season. Later application of foliar insecticides for GPA or CPB will kill cutworms. Natural predators include parasitic wasps, tachinid flies, and diseases.

Flea Beetles (*Epitrix cucumeris*)(FB)

Two species of the flea beetle are a problem in Montana: The potato flea beetle (*Epitrix cucumeris*) and the western flea beetle. Adult beetles are typically small, often shiny, and have large rear legs. Flea beetles overwinter in the adult stage hidden under leaves, dirt clods, or in other protected sites. Many flea beetles are strong fliers and locate emerging host plants by chemical cues the plants produce. They lay eggs in soil cracks around the base of the plants. The tiny, worm-like larvae feed on small roots and root hairs of the plant. The larval stage last about a month when the insect pupates and emerges from the soil as an adult. There may be a second generation during the summer. Flea beetles produce a characteristic injury known as "shotholing." The adults chew many small holes or pits in the leaves. Young plants and seedlings are particularly susceptible, growth may be seriously retarded, and plants even killed. Systemic insecticides and foliar sprays applied for GPA and CPB typically control the flea beetle.

Potato Tuberworm (*Phthorimaea operculella*) (PT)

The potato tuberworm (*Phthorimaea operculella*) has two life cycles. The adult is a small, slender moth with narrow, gray forewings with brown spots and the hind wings are yellowish brown. The adult lays up to 200 eggs over a four day period on the underside of potato leaves or the tuber eyes where the larvae hatch three to six days later. The larvae matures at one-half inch in length and is pinkish white with a brown head. The larvae then feeds on the stems, leaves, and tubers for the next seven to ten days. Shoots that have been damaged wilt and die. Small papery, grayish blotches will appear on typically the older leaves and the tubers will have deep tunnels drilled in them. The tuberworm covers the opening of the tunnel with a fine web making it difficult to detect. After the larvae matures it pupates in the soil near the base of a plant and six to nine days later a new generation of tuberworms emerge. Five to six generations can occur during a growing season.

Natural enemies of the potato tuberworm larvae include two braconid wasps (*Orgilus lepidus* and *Bracon Gelechia*). Insecticides can be used to control the insect in the field but there are not registered chemical control in stored potatoes.

Gray garden slug (*Agriolimax reticulatum*) (GGS)

The gray garden slug (*Agriolimax reticulatum*) is a member of the mollusks family that lack an external shell. This slug is about ¼" to ½" inch long. It ranges from gray to black with a slimy material that protects it from drying out. This slimy material leaves a white shiny slime trail. The slug feeds at night on young emerging seedling, typically causing heavy damage to seedlings that result in death to the plant. Slugs are bisexual and lay eggs in the fall where they hatch and winter over or in the early spring. Slugs mature in about one year. Baits containing insecticides should be applied in the fall just before rains begin to kill slugs before they lay eggs.

Wireworms (*Limonius californicus*, *L. canus*, *Ctenicera pruinina*)(WW)

Wireworms are the larval stage of a family of beetles commonly called click beetles. Adults are brownish or even blackish in color, elongate and tapering toward each end but more so toward the rear. The earliest stages of larvae 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. The larvae mature from two to five years. Wireworms usually overwinter in the adult stage. Females deposit eggs in the soil. During the potato growing season, wireworms typically stay in the top two to three inches of the soil. However, during the winter months they move up to two feet into the soil. Fully developed larvae form pupation chambers in the soil and pupate. Adults emerge from the pupae and 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.

Detecting wireworm infestations and determining populations can be difficult. Baiting gives a poor estimate of population sizes, but is a quick method to determine the presence of wireworms. Soil assay procedures are available to estimate the number of wireworms per square foot. If wireworm infestations become a problem, a preplanting insecticide can be incorporated into the soil followed by side-dressing. If two applications are necessary, different types of insecticides should be used. Wireworms are not a major concern in Montana.

Miscellaneous Insects - The following insects are occasionally found in Montana but are not considered a major problem.

Blister Beetle (*Epicauta spp*) (BB)

In the western states, potato fields located adjacent to rangeland, experience crop damage from the blister beetle. The adult beetle has a conspicuous head and the first segment of the thorax of the adult beetle is narrow and neck like. The wing covers are soft and do not completely cover the abdomen. The adult feeds on the upper leaves and flowers, of the plants leaving ragged leaves and stunted plants generally in small areas of a field. These insects generally leave the field before detection or chemical application. The blister beetle larvae become parasites of grasshopper and ground-nesting bees' eggs.

Loopers (*Autographa californica*) (*Trichoplusia ni* (Hübner)) (LP)

Loopers feed on the older, mature leaves later in the season and have little impact on the crop value. The looper is usually found on the leaves of plants. Two species are found on the potato: the cabbage looper *Trichoplusia ni* (Hübner) and the alfalfa looper (*Autographa californica*). Both species are light green with narrow stripes on their back. When they crawl, their back arches into a loop. In addition to natural predators and diseases, insecticides applied for GPA and CPB will control loopers. Systemic insecticides may increase the appearance of loopers in some areas.

Potato Psyllid (PP)

The adult is an active, small clear-winged insect with prominent eyes and well-developed legs. The 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, injecting a toxin in the process. Potato psyllid excretes a granular material that resembles salt or sugar, a good indicator of the insect's presence. 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 stop growing. Affected potatoes produce many small unmarketable tubers with rough skins tending 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.

Beneficial Insects

Lady Beetles (Lady Bugs) (*Hippodamia convergens*)

Ladybugs (*Hippodamia convergens*) is the most commonly known of the beneficial insects. The small red bug with black spots. It feeds on aphids, chinch bugs, Colorado potato beetle larvae, as well as many other soft-bodied insects and eggs. The female ladybugs lays ten to 50 eggs daily on leaves near their intended prey. The larvae emerges in 2-5 days as a dark alligator-like worm with orange spots. The larvae eat 50 – 60 aphids per day. At the end of 21 days the larvae pupate and depending on the temperature emerge as an adult in 2-8 days. Several generations may be produced during a season.

Green Lacewing (*Chrysoperia sp*)

The green lacewing (*Chrysoperia sp*) is a delicate flying insect with pastel green wings. The larvae feed on aphids and leafhopper nymphs for 1 – 3 weeks when they become adults. The adults eat only honey, pollen and nectar that is needed for reproduction.

Aphid Predator (*Aphidoletes aphidomyza*)

The aphid predator (*Aphidoletes aphidomyza*) is a small gnat-sized insect that lays up to 250 eggs within 10 days. The larvae hatch within ten days, grow up to 1/8 inch long and can kill from 4-65 aphids per day. These insects are more effective at 68-80°F. After 3-7 days the larvae burrow into the soil to pupate.

Aphid Parasite (*Aphidius matricariae*) (*Aphidius colemanii*)

The aphid parasite (*Aphidius matricariae*) is a small parasitic wasp that feeds primarily on the green peach aphid but also preys on many other aphid species other than the potato aphid. This wasp is a native of North America and is very good at locating new aphid colonies when aphid populations are low. The female wasp will attack up to 300 aphids. The egg will hatch and mature to the adult stage from ten days to two weeks depending on the temperature.

The Aphipar (*Aphidius colemanii*) is a small parasitic wasp that parasitizes green peach aphid and up to 40 other aphid species. This wasp is a native of North America and is very good at locating new aphid colonies when aphid populations are low. The female wasp will lay about 100 eggs in aphids while attaching up to 200-300 aphids. The egg will hatch and mature to the adult stage from ten days to two weeks depending on the temperature.

Insecticides			
Contact the Montana Department of Agriculture for registration information			
Product	Rate	PHI*	Remarks
<i>Abamectin</i>			
Agri-Mek 0.15EC	8.0 to 16.0 fl. oz/acre	14	Do not exceed 32 fl oz. of Agri-Mek per acre per crop for spider mite or Colorado potato beetle control. Do not apply in less than 20 gals. of water per acre. Do not graze or feed treated foliage to livestock. Do not make more than 2 sequential applications.
<i>aldicarb</i>			
Temik 15 G	20 lb (GPA)	150	RESTRICTED USE PESTICIDE At-plant only. Positive displacement applicators only. Do not allow livestock to graze in treated areas before harvest
	20 lb (Flea Beetles)		Apply granules with the seed pieces in the planting furrow and cover with soil. Do not exceed a total of 20 lbs/acre. Apply only with positive displacement applicators.
	14 to 20 lb (CPB)	150	RESTRICTED USE PESTICIDE At-plant only. Positive displacement applicators only.
<i>Azinphos - methyl</i>			
Guthion 2L	1.5 pts (CBP) 2 to 3 pts (Flea beetle Leafhoppers) 2 1/4 to 3 (tuberworms)	7	RESTRICTED USE PESTICIDE A total of 3 applications may be made per crop season regardless of rate, formulation or method of application. Resistance of CPB has occurred in some areas.

<i>Bacillus thuringiensis M-Trak</i>	2 to 4 qt		Make initial spray when eggs hatch and small (less than 1/4 inch long) larvae are first observed. Rates vary based on infestation level - see label. For large larvae and adults use other labeled products.
<i>Bacillus thuringiensis spp. Tenebrionis</i> Novodor, DiPel2X; DelPol4L; M-Trak; Biobit W; Biobit F; Javelin WG; Xentari	(see label for rates)	0	Use a spreader-sticker. (see label for rates)
<i>bioinsecticide</i>			
Match	(see label)	0	A bioinsecticide with a blend of derived delta entotoxins of Bt encapsulated in killed <i>P. fluorescens</i>
<i>carbaryl</i>			
Sevin	Rate varies by formulation used		Sevin 80S is labeled for center pivot application at 2 lb ai/a. Cutworms and the fall armyworm only
<i>carbofuran</i>			
Furadan 4F	1 – 2 pts/A	14	RESTRICTED USE PESTICIDE Do not make more than 2 foliar applications per season. Can be applied as a banded spray or shanked in depending on irrigation system. Do not make any other Furadan applications if this application is used.
<i>Cryolite</i>			
Kryocide 96W	8-16 lb/acre	14	Do not exceed 64 lbs. per acre per season.
<i>Cyfluthrin</i>			
Baythroid 2 RU	0.8 – 2.8 fl oz/A	0	RESTRICTED USE PESTICIDE Apply a total of 6 applications per crop season. Resistance in some insects has been found.
<i>Diazinon</i>			
D-Z-N 50w	10 gals/acre	35	RESTRICTED USE PESTICIDE ground application See label for specific insect control
Bimethoate 400	5 gals/acre		RESTRICTED USE PESTICIDE Aerial application See label for specific insect control
Digon 400	0.25 to 0.5 lb		Has systemic and contact activity. May not control certain organophosphate resistant species.
<i>Disulfoton</i>			
DiSyston	1 to 3 lb	30-60	When applied through sprinklers. Do not make more than two soil applications per season.

	2 to 3 lb	75	Apply by banding each side of seed piece at planting time or by sidedressing after emergence. No more than two applications per season. See label for rotational crop restrictions.
	3 lb	75	Apply 3 lb broadcast by air and immediately incorporate with sprinkler water. See label for full details. Do not make more than two soil applications per season.
	3 to 4 lb	75	Apply 3 to 4 lb as a pre-plant broadcast treatment. Incorporate to a depth of 2 to 3 inches. Or apply 2 to 3 lb at time of planting by banding or injecting each side of seed furrow. An additional application also may be made as a sidedress treatment after plants become established using either granules or liquid. Do not make more than two soil applications per season. See label for full details.
Endosulfan			
Endocide, Thiodan, Phaser	2/3 to 1 1/3 qt/ acre	1	Do not plant root crops other than carrots, potatoes, or sweet potatoes as followup crop. Thiodan is more effective at temperatures above 75 F. Do not exceed 3 lb ai/a per year Do not make more than 6 applications per year.
Ensfenvalerate			
Asana XL	Rates vary by insect	7	RESTRICTED USE PESTICIDE Do not exceed 0.35 lb ai/a per season. Do not graze livestock on treated vines
Enstar II			
			Insect growth regulator
Ethoprop			
Mocap 10G or EC	40 - 60 lb/acre		Preplant or at planting
Imidacloprid			
Gauche 75ST, Genesis			Seed piece treatment
Admire 2F	0.9 to 1.3 fl oz/1,000 row ft		Use only at planting as a band spray during bed formation or spray seed pieces in furrow for best results. Do not apply more than a total of 0.31 lb ai/a per season of Admire or Provado. Observe any restrictions relating to subsequent crops planted in ground receiving Provado or Admire applications.
Provado 1.6F	0.05 lb	7	Ground applications only. 7 days between applications. Do not apply more than 0.2 lb ai/a per season. Do not apply more than a total of 0.31 lb ai/a per season of Admire or Provado. Observe any restrictions relating to subsequent crops planted in ground receiving Provado or Admire applications
	3.75 fl oz of product	7	
Malathion			
Cythion	1 to 3 lb	0	
Methamidophos			

Monitor 4	1.5 to 2 pts/ acre	14	RESTRICTED USE PESTICIDE Warning: if methamidophos (Monitor) or carbaryl (Sevin) are allowed to drift onto adjacent legume or vegetable seed crops, they are highly hazardous to pollinating bees. Alternate materials should be used under such conditions. Apply specified dosage per acre. Maximum application of 8 pts/acre per season
Methoxychlor			
DMDT, Marlate, Metox	1 to 2.25 lb	0	
methyl-parathion			
Penncap-M	2 to 4 pts/acres	5	
oxamyl			
Vydate L	1 to 4 pt/acre	7	RESTRICTED USE PESTICIDE Do not apply more than 24 pts per acre per season or 6 applications per crop.
Permethrin			
Ambush	0.05 to 0.2 lb ai/acre	14	RESTRICTED USE PESTICIDE Do not exceed 1.6 lb ai/a per season. Do not graze or feed.
Pounce 3.2E; Pounce 25W	0.1 to 0.2 lb ai/ acre	14	RESTRICTED USE PESTICIDE Do not exceed 1.6 lb ai/a per season. Do not graze or feed.
Phorate 15g			
Thimet 20G	2.3 to 3.5 oz ai/1,000 row ft	90	RESTRICTED USE PESTICIDE Apply in furrow or sidedress at planting. Light soils 2 lb; heavy soils 3 lb.
Phosmet			
Imidan	1 1/3 lb	7	Do not apply more than 6 2/3 lbs per acre per crop season. Use only on potatoes to be harvested by machine.
Potassium salts			
M-Pede	2% solution (see label for GPA)	0	Potassium salts of fatty acids
Pymetrozin			
Fulfill 50% water- dispersible granule	2.75 oz./acre foliar application	14	Apply when aphids first appear, before populations build to damaging levels. Thorough spray coverage is essential for optimum control - use a minimum of 20 gals/acre. Do not apply by air. Do not make more than two applications per crop season; do not exceed a total of 5.5 oz./acre per crop season. Allow a minimum of 7 days between applications.
Trident SC	0.32% ai/gal - 4 qt	0	Most effective on 1st and 2nd instar larvae. Apply immediately after egg hatch. Good coverage important. Improved control with the addition of pinolene (spreader-sticker). Effective only on Colorado potato beetle. If high populations of large larvae are present, use an effective contact insecticide

* DBH Days before Harvest * PHI - Post Harvest Interval

Compiled date from The Greenbook, Crop Data Management Systems, and Insecticides registered in Potatoes in the Northwest websites. **Contact the Montana Department of Agriculture for use in Montana**

Cross Reference Insecticide: Chemical with Product Name

Contact the Montana Department of Agriculture for registration information

Chemical	Product
abamectin	Agri-Mek 0.15EC
aldicarb	Temik 15 G
Azinphos - methyl	Guthion
Bacillus thuringiensis	Novodor, DiPel2X; DelPol4L; M-Trak; Biobit W; Biobit F; Javelin WG; Xentari
bioinsecticide	Mattech
carbaryl	Sevin, Aventis
carbofuran	Furadan 4F
Cryolite	Kryocide 96W
Cyfluthrin	Baythroid
Diazinon	D-Z-N
Dimethoate	Bimetoate 400, Digon 400
Disulfoton	DiSyston
Endosulfan	Endocide, Thiodan, Phaser
ensfenvaterate	Asana
Ethoprop	Mocap 10G or EC
fonofos	Dyfonate 4E; Dyfonate II 15G; Dyfonate #10G
Imidachloprid	Admire, Provado, Gaucho, Genesis
Insect Growth Regulator	Enstar II
Malathion	Cythion
Methamidophos	Monitor
Methomyl	Lannate
Methoxychlor	DMDT, Marlata, and Metox
methyl-parathion	Pennacap-M
Neem seed extract	Azatin, Neemazad, Neemix, Natural pyrethrums
oxamyl	Vydate L
permethrin	Ambush 2E; Ambush 25W, Pounce 3.2E; Pounce 25W

Phorate	Thimet
Phosmet	Imidan
Potassium salt soap	M-Pede
pymetrozin	Fulfill 50% water-dispersible granule
Spinosad	Spin T or 2SC, Success 2EC

Insects in Montana and Insecticides registered for potatoes

Contact the Montana Department of Agriculture for registration information

Insect	Insecticide
Green Peach Aphid (GPA)	Aldicarb, Carbofuran, Cyfluthrin, Diazinon, Dimethoate, Disulfoton, Endosulfan, Imidachloprid, Malathion, Methamidophos, Methomyl, Oxamyl, Potassium salt soap, Phorate, Pymetrozin
Potato Aphid	Aldicarb, Carbofuran, Cyfluthrin, Diazinon, Dimethoate, Disulfoton, Endosulfan, Ensfnvalerate, Imidachloprid, Malathion, Methamidophos, Methomyl, Oxamyl, Potassium salt soap, Phorate, Permethrin, Pymetrozin
Wireworm	Diazinon, Phorate, Ethoprop, Carbofuran
Colorado Potato Beetle (CPB)	Abamectin, Aldicarb, Azinphos-methyl, Bacillus thuringiensis, Carbaryl, Carbofuran, Cryolite, Cyfluthrin, Diazinon, Disulfoton, Endosulfan, Ensfnvalerate, Imidachloprid, Methamidophos, Methoxychlor, Methyl-parathion, Oxamyl, Permethrin, Phosmet, Phorate, Spinosad
Cutworms	Bacillus thuringiensis, Carbaryl, Cyfluthrin, Ensfnvalerate, Maatch, Methamidophos, Methomyl, Methyl-parathion, Permethrin
Flea Beetle (Potato & Western)	Azinphos-methyl, Carbaryl, Carbofuran, Cyfluthrin, Diazinon, Disulfoton, Endosulfan, Ensfnvalerate, Imidachloprid, Malathion, Methamidophos, Methomyl, Methoxychlor, Methyl-parathion, Oxamyl, Permethrin, Phorate, Phosmet
Gray Garden Slug	Mesurol 2%, Sevin, Cryolite
Potato Tuberworm	Cyfluthrin, Endosulfan, Ensfnvalerate, Guthion 2L, Permethrin
Occasional Problem Insects	
Potato Psyllid	Cyfluthrin, Endosulfan, Ensfnvalerate, Imidachloprid, Methamidophos, Permethrin, Phorate 15g
Loopers (Cabbage & Alfalfa)	Azinphos-methyl, Cyfluthrin, Ensfnvalerate, Imidachloprid, Permethrin, Carbaryl
Blister Beetles	Malathion, Methoxychlor

Diseases

Disease management is probably the most important tool in crop management. Diseases affect every stage of the potato life span. Potato diseases reduce seedling stands, cause leaf spots, wilts, storage rots, and are carried by the seed tuber from one crop to the next. Disease resistant varieties are being developed in Montana to assist commercial growers. While disease resistant varieties assist in the management of diseases, it is critical that the best cultural and sanitation practices be included in the growing program to decrease the spread of these diseases. Zero tolerance is allowed in seed crop production.

Fungal Diseases

In addition to cultural practices, potato producers use fungicides to control disease in their crops. There are two main types of fungicides used to control diseases. Contact fungicides or protectant fungicides, work on the surface of the plant to protect against infection. Systemic fungicides are absorbed into the plant tissues controlling fungal diseases from within the plant tissue.

Protectant fungicides kill germinating fungus spores to prevent infection, but cannot protect against systematic infections, such as wilts and virus diseases. Protectant fungicides are used for seed piece treatment and to protect against foliar diseases, primarily early and late blight. They cannot prevent disease development once infection has occurred and must be present on the leaf before infection occurs.

Systemic fungicides work after the plant has been infected. Many systemic fungicides target certain fungi and have a limited broad spectrum activity compared to protectant fungicides. Systemic fungicides tend to move upward through the plant to the outer edges of the leaves. Fungi can quickly develop resistance to certain fungicides. Applying a pre-mixed fungicide may help slow the fungicidal resistance.

Late blight (*Phytophthora infestans*)

Late blight (*Phytophthora infestans*) is the most damaging potato disease worldwide attacking both tubers and foliage during any stage of crop development. The first evidence of late blight was found in Montana in 1995. This disease spreads through diseased seed potatoes, in both private gardens and in commercial potato operations and has the potential to devastate commercial potato crops. Late blight is a serious threat to potato seed producers in Montana. Recent findings show new strains of the late blight fungus that are resistant to what had been very effective and commonly used fungicides. Because of the high potential for loss, monitoring crops and implementing controls for this disease is essential.

This fungus is airborne, waterborne, and seedborne coming from such sources as seed, cull piles, and volunteer potatoes. The disease affects all members of the potato family (*Solanaceae* and) including potato, tomato, pepper, and nightshades and spreads from weeds to crops. Late blight disease develops best in high moisture and moderate temperatures for periods of several hours. These conditions can cause complete blighting of foliage within a very short time. Night temperatures of 50-60° F and day temperatures of 60-70° F are most favorable for disease development. Rain, dew, sprinkler irrigation, and high relative humidity (greater than 90 percent) may all provide favorable conditions. The spores require water to germinate and penetrate the potato tissue. Because of this relationship, spores or lesions are most apparent after wet nights or periods of rainfall. The spores, carried by wind and rain, infect healthy plants and repeat their reproductive cycle many times throughout the season.

Damage

The first symptoms of late blight in the field are small, light to dark green, circular to irregular-shaped water-soaked spots on leaves, becoming purplish-black with a yellowish halo. These lesions usually appear first on the lower leaves within a few days after infection. Lesions often begin to develop near the leaf tips or edges, where dew is retained longest. During cool, moist weather, these lesions expand rapidly into large, dark brown or black lesions, often appearing greasy. Leaf veins do not limit the lesions, and as new infections occur and existing infections coalesce, entire leaves can become blighted and killed within just a few days. The lesions may expand down petioles and stems of the plant. Examining the underside of infected leaves while the air is cool and damp, may show a white growth at the edge of the lesions. This will identify it from several other foliar diseases of potato.

Late blight fungus can only survive in living infected potatoes, including potatoes in storage, infected tubers missed during harvest and remaining unfrozen over the winter (volunteers), and infected cull piles. Infected tubers do not break down when stored cold (38°F) and can act as a source of blight in the field when planted. The majority of the affected seed tubers decay due to secondary soft rot in the field at planting, but the few infected seed pieces that grow can start an epidemic under favorable conditions.

The infected tubers have irregularly shaped, slightly depressed areas of brown to purplish color of variable size on the skin. These symptoms may be less obvious on russet and red-skinned cultivars. A tan to reddish-brown, dry, granular rot is found under the skin in the discolored areas, extending into the tuber usually less than one half inch.

The margin of the diseased tissue is not distinct. The margin is marked by brown finger-like extensions into the healthy flesh of the tuber. Severely infected tubers may display extensive rot, often accompanied by soft rot. The mildew-like growth of the causal fungus may appear on the surface of tubers.

Control

Effective control of this disease requires implementing an integrated disease management approach. Cultural

practices are the first line of defense against this disease followed by the use of resistant cultivars and chemical controls.

Cultural practices

Do not transport potatoes into Montana from other states.

- 2) Destroy and bury cull potatoes, diseased plants, and volunteer potato and tomato plants.**
- 3) Control weeds adjacent to potato fields.**
- 4) Avoid frequent or night-time overhead irrigation of potatoes.**
- 5) Kill potato foliage 10 days to two weeks before harvesting.**
- 6) Hilling will reduce the incidence of tuber infection.**
- 7) Remove infected tubers before storage to reduce additional losses from soft rot.**
- 8) Tubers should be dry when placed in storage. Monitoring for storage temperature and evidence of late blight.**

Fungicides

Research indicates that fungicide applications are most successful if they start when the canopy begins to close within the row. Protectant fungicides are applied for prevention and complete coverage is critical. If the disease is present, a combination of protectant and systemic eradicator fungicides should be used. The late blight fungus has shown the ability to develop strains that are resistant to some systemic/eradicator fungicides. Resistance to protectant fungicides has never been identified. Because of this threat, eradicator fungicides should always be applied in combination with protectants. New strains of late blight fungus are resistant to the most effective fungicide and could be capable of sexual reproduction and possibly long-term survival in soil and crop residues.

Early blight (*Alternaria solani*)

Early blight is a common fungal disease in potatoes found in all potato growing regions. It is most severe on maturing or nutritionally deficient potato vines causing severe defoliation and loss of yields and tuber quality in storage. The most susceptible varieties include Delaware and Russet Burbank. The disease can persist in potato crop debris, soil, infected tubers, or other members of the potato family (*Solanaceae* and) including tomato, pepper, and nightshades. In contrast to late blight, early infections by *A. solani* are typically unimportant and the disease does not become important until the leaves become older.

Damage

Early blight is often more prevalent on older, senescing tissues and particularly when plants have been predisposed by injury, poor nutrition, insect damage, or other type of stress. The first signs of infections are small dark spots on the older leaves on the lower portions of plants. As these spots enlarge, they develop concentric rings of raised and depressed necrotic tissue, giving a target effect. Advanced lesions often have angular margins because of limitation by leaf veins. There is usually a yellowish zone around the spots that fades into the normal green of the leaves.

Multiple infections are common and rapidly cover the whole leaf. Primarily windborne, spores are primarily produced on debris or infected cultivated crops, infecting healthy potato leaves during warm temperatures and high humidity. The germinating spores penetrate susceptible tissue directly or through wounds. Periods of alternating wet and dry weather favor spore dispersal and disease spread. Because of the relative resistance of young to intermediate-aged potato plants, major outbreaks of disease do not occur until late in the season.

Tuber infection occurs less frequently than leaf infection. Initial tuber infection results from superficial wounds in the skin. The infection produces depressed leathery, dark gray lesions about 1/3 inch in diameter, surrounded by puckered skin and developing as a dry rot in storage. In advanced decay, the tissue is often water-soaked and yellow to greenish yellow. Lesions can enlarge during storage, and tubers can become shriveled in advanced cases. Infestation of the tuber begins during harvest when foliage comes in contact with the tubers, or when there is digging damage. If sufficient moisture is present, spores can germinate and infect tubers. Immature tubers are particularly susceptible to early blight.

Control

Effective control of this disease requires implementing an integrated disease management approach. Cultural practices are the first line of defense against this disease. Resistant cultivars and chemical controls can also be utilized. No cultivars are immune to infection. Some cultivars, such as Red Norland, Norchip, and Superior are more susceptible to the disease and should be avoided in areas where early blight is a major concern. Late maturing cultivars are usually more resistant than early maturing cultivars; therefore, one should avoid planting early and late varieties in the same or adjacent fields.

Cultural practices

- 1) Crop rotation
- 2) Removal and burning of infected plant debris.
- 3) Eradication of weed hosts
- 4) Avoid irrigation in cool, cloudy periods as well as during the hottest hours of the day.
- 5) Kill potato foliage 10 days to two weeks before harvesting.
- 6) Store tubers under conditions that promote rapid suberization to minimize tuber infection after harvest.
- 7) Protect against insect infestations
- 8) Maintain high soil fertility.

Fungicides:

The most common and effective control method of early blight is the application of foliar fungicides. The protectant fungicides recommended for late blight are also effective against early blight when applied at approximately 7-10 days intervals. Regular inspection of fields after plants reach 12 inches in height is recommended in order to detect early infections. Spraying should commence at the first sign of disease or immediately after bloom. Protectant fungicides should be applied initially at relatively long intervals and subsequently at shorter intervals as the crop ages. Early blight can be controlled by relatively few fungicide applications if the initial application is properly timed.

Common Scab (*Streptomyces scabies*)

Common scab is a fungus causing severe damage to the appearance or quality of tubers but displays no visible symptoms on the foliage. Superficial wounds on the tubers appear brownish, approximately one-quarter inch in diameter. The blemishes can appear on the surface, raising the peel slightly or causing slight depressions. This disease is present to some extent in most areas where potatoes are grown and is a major production problem that affects grade quality but has only a small effect on total yield or storing ability. It is seen in irregularly irrigated crops, either as prominent galls or as corky depressions. Unlike powdery scab, this disease is favored by dry conditions and is most common on spring and summer crops. Common scab spreads rapidly in dry alkaline soils. Temperatures conducive to infestation are 68-72°. Common scab infests soil and propagating material.

Sulphur can be added to the soil to lower soil pH and manganese applications have reduced scab. Also the reduction of the calcium-phosphorus ratio of the soil has reduced scab severity. Chemical treatment of the soil depend on the proper incorporation of chemicals into the soil and should be coordinated with other prevention methods.

Cultural practices

- 1) Using disease-free seed tubers.**
- 2) Medium-to-long crop rotations.**
- 3) Varietal resistance.**
- 4) Accurate timing of irrigation, to prevent the soil drying out during tuber growth.**
- 5) Maintaining field capacity suitable for potato cultivation.**
- 6) Avoiding over liming of soil which increases soil pH and lowers soil Ca-P ratio.**

Potato Leaf Roll Virus (PLRV)

Potato Leafroll Virus (PLRV) is a persistent virus vectored by several aphid species, of which, the green peach aphid (*Myzus persicae*) is the most important. PLRV continually presents major problems in seed potato certification due to viral perpetuation in seed tubers. Because of low PLRV tolerances in certified seed, intensive measures are taken to limit aphid populations.

Damage

Foliar symptoms of PLRV include inward curling of the upper leaves, sometimes extends to the lower leaves, stiffening of the leaves such that they may stand upright, chlorosis (yellow or slightly pinkish), reddening, 'leathering' of leaves, and phloem necrosis. Infected plants are usually stunted and stand upright. Plants infected early in the growing season may also be dwarfed, but if virus infection occurs late in the growing season foliar symptoms may not be exhibited. Potato plants develop resistance to foliar infection with plant age. Many times, infection can be seen in a circular pattern in the field, frequently surrounding what was most likely the original

source of virus inoculum, an infected seed piece. Direct damage can also result from aphid feeding. Large numbers of aphids present can kill potato plants. PLRV travels through the phloem of the plant into tubers, reducing size and causing net necrosis.

Control

Effective control of this disease requires implementing an integrated disease management approach. Cultural practices are the first line of defense against this disease. Because PLRV is not mechanically transmitted, aphids are solely responsible for the in-season spread of the virus. Therefore, the management of aphids is an integral part of the management of PLRV. Virus spread can be controlled by protecting beneficial arthropods by using pesticides only as warranted, and using selective insecticides where feasible. Three circumstances exist in which the control of aphids may be necessary; the elimination of virus vectors during seed production, when cultivars susceptible to net necrosis such as Russet Burbank are grown, and during aphid population outbreaks. Aphids frequently occur due to insecticide resistance and the elimination of natural enemies.

Production of seed potatoes requires thorough aphid control and extra sanitation practices. The treatment threshold in Montana requires a preplant application of systemic insecticides. Fields are closely watched for aphid infestation. It is recommended that a minimum of five samples per forty acres plus an additional one sample per ten acres be taken. If one aphid is found in a field, wait one week and sample again. If aphids are still observed the field should be treated. Mustards, sunflowers, and nightshades, should be eliminated in the field and surrounding areas as aphids will appear on these weeds before moving into the potato crop.

Natural pests of the aphid include predators, parasites, and fungal pathogens. Predatory insects such as the ladybird beetles, lacewings, minute pirate bugs, hover flies, damsel bugs, and seed bugs are much more effective at controlling aphids than parasites. Both fungicides and insecticides are damaging to populations of aphids natural enemies. All major fungicides registered for the control of late blight kill beneficial fungi, increasing aphid populations dramatically. Mancozeb sprayed routinely can cause aphid populations to rise to 100 times those receiving no fungicide applications. Beneficial fungi offer possibilities for the biological control of aphids in the future, but high rates of fungicides used on potatoes limit the possibility of fungi as biological control agents.

Cultural Practices

- 1) Planting virus-free certified seed
- 2) Killing volunteer potatoes (key source of virus) and weed host.
- 3) Burning infested plants.
- 4) Early rouging of infected plants and surrounding plants.
- 5) Control of aphids.

Net Necrosis

Net necrosis causes browning of the vascular system extending throughout the potato and can cause severe losses in commercial potato crops. Net necrosis is primarily seen when the potato leaf roll virus (PLRV) is spread to healthy plants by aphids. Management of net necrosis is heavily dependent upon managing aphid populations.

Net necrosis may or may not be found before harvest, possibly developing or becoming more severe in storage. Timing of the development of net necrosis is dependent upon the time in the growing season at which plants become infected. Tubers produced by plants infected with PLRV early in the growing season, June or July, may exhibit net necrosis at harvest. Plants infected in August or later will not likely exhibit symptoms of net necrosis at harvest, but develop symptoms later in storage. Also, plants infected with PLRV during the tuber bulking stage of growth in late July and early August are more likely to develop net necrosis. Differences in severity of net necrosis can be seen among virus strains. Net necrosis does not threaten all potato cultivars, but is a major problem in infected Russet Burbank tubers with a high percentage of crops intended for processing. Net necrosis has also been identified in Green Mountain and Russet Norkotah. Kennebec does not develop net necrosis. Control of PLRV includes the isolation of fields targeted for certified seed production, the use of clean seed, control of aphids, removal of infected plants, and early harvest.

Cultural Practices

- 1) Kill potato foliage 10 days to two weeks before harvesting.
- 2) Aphid control.

Potato Virus X (PVX)

PVX is the most widespread of the potato virus. Prior to 1976, all of the varieties of potatoes grown, primarily Russet Burbank, were infected with PVX. Some strains of the virus PVX produces no visible symptoms in the tubers and plants but causes about a twenty-five percent reduction in yield. Other strains cause mild mottling, chlorotic (yellowish) veins, decrease in size of the leaves, mosaic in the leaves and necrotic lesions in tubers. It is also known as potato latent virus, potato mottle virus, and latent mosaic. Infected tubers cannot be used for propagation. Transmission of the virus can be by wind, animals, mechanical devices, cutting blades, contact between plants or plant roots, and tubers. There are no known aphid vectors. A combination of PVX, PVY and PVA can cause more severe symptoms. The spread of potato virus X can be controlled by cultural practices.

At this time, all of Montana's seed potatoes are free of this virus.

Cultural Practice

- 1) Using certified seed tubers.
- 2) Avoiding mechanical transmission.
- 3) Burning infested plants.
- 4) Restricting movement in infested fields.

Potato Virus Y (PVY)

Potato Virus Y (PVY) is the most severe of the potato viruses. It is also known as potato vein banding virus. PVY results in severe mosaic, leafdrop streak, and when PVX is also present, rugose mosaic. Vein binding is the development of brown streaks along veins on the underside of leaves causing lower leaves to die and spotting and severe malformation of the upper leaves. PVY also results in shortening of the stem internodes, defoliation, and early plant death. Rugose mosaic is characterized by a severe wrinkling of the leaves, veins are sunken and interveinal areas raised. This virus results in a yield reduction and the tubers cannot be used for propagation. The host range for PVY includes tomatoes, legumes, nightshades, pigweeds, and other weed species. The only over-wintering source of PVY is infected potato tubers. The virus is also transmitted by aphids, the green peach aphid being the most important.

Cultural Practices

- 1) Plant certified seed tubers.**
- 2) Eliminate cull piles.**
- 3) Control potato volunteers and weeds.**
- 4) Prevent buildup of aphid populations.**

Calico

Calico, also known as alfalfa mosaic virus, is commonly seen wherever potatoes are grown. This virus causes yellowing of the leaves known as calico and may cause necrosis in the tubers. Some strains of the virus cause cell necrosis in the stems and tubers, rather than the pale to bright yellow mottling or blotching of leaf surfaces. This virus is relatively unimportant unless potatoes are planted next to an alfalfa or clover field. Aphids migrating from alfalfa fields into potato fields spread alfalfa mosaic virus.

Cultural Practices

- 1) Plant certified seed tubers.**
- 2) Avoid planting near alfalfa or clover fields.**
- 3) Remove calico plants as soon as they appear.**
- 4) Control aphid investigations.**

Giant Hill

Giant Hill is considered a genetic abnormality resulting larger, coarser plants with smaller leaves, and more vigorous vines than normal potatoes. These plants mature more slowly, and their tubers tend to be larger and coarser than normal potatoes. Due to the late maturing of these plants and the early foliage destruction of certified seed crops, this genetic abnormality is not detected and is passed on to commercial growers.

Haywire

Haywire, also known as aster yellows, is a mycoplasma infection that occurs worldwide but is of minor

importance in the western states. Haywire causes the upper leaflets to roll and develop purple or yellow pigmentation. Plants infected with Haywire may cause stunting and premature death, aerial tubers are common, and occasionally some proliferation of axillary buds. Lower stems frequently develop cortical necrosis, shredding of tissue and vascular discoloration. Often only a single stem in a hill is affected and at harvest will have both mature and immature tubers. The disease is transmitted by leaf hoppers that have fed on infected plants two to three weeks before feeding on the potato plant. Over 350 species of plants, from at least 54 families as susceptible to aster yellows.

Cultural Control

- 1) Pesticide control of leaf hoppers

Witches' Broom

Witches' broom, also known as northern stolbur and dwarf shrub virosis, is a mycoplasma infection, of minor economic importance though found in North America, Europe, and Asia. Leaves on infected plants may curl and discolor similar to those infected by leafroll. Mycoplasma survives in the tuber. Affected hills usually produce normal appearing tubers the first year. When infected tubers are planted they develop numerous stems with small, round leaves and produce large numbers of pea-sized tubers. Because no useful tubers are produced this disease is self-eliminating. Mycoplasma is transmitted by leaf hoppers (*Sclerorachus* genus). Control of the disease is typically limited to pesticide control of leaf hoppers.

Cultural Control

- 1) Pesticide control of leaf hoppers.

Verticillium Wilt (*Verticillium dahliae*)

Verticillium wilt is widespread in all potato growing areas especially in areas where susceptible varieties such as Kennebec and Russet Burbank are grown. This disease results in a significant decrease in yield, but without damage to visual quality. The common symptom of verticillium wilt is known as, 'early dying' or 'early maturity'. The symptoms of this disease begin to appear late in the season, when older, lower leaves become yellow, curl and roll, show tip burn, and then die. The inside of the plant stem turns yellow or brown.

Tubers from infected plants usually develop light brown discoloration in the vascular ring and may extend over

halfway through the tuber. Cavities may develop inside severely affected tubers. Pinkish or tan discoloration may develop around the eyes or as irregular blotches on the surface of affected tubers. Seed tubers carry the pathogen in their vascular bundles and can transmit the disease. The fungus penetrates through plant roots, wounds, and through sprout and leaf surfaces. It becomes established in the vascular bundles, and spreads systemically. Disease severity can be enhanced by the presence of free nematodes (*Pratylenchus*) in the soil or of *Erwinia* (the pathogen responsible for black foot disease) in the mother tubers, or by irrigating with saline water. Warm soil temperatures (72-80°F) favors growth of *Verticillium dahliae*.

Again, prevention is the best management tool, although applications of a sulfur fungicide every 7-10 days will help in control. Infested potato plants that have dried out infest the soil with micro-sclerotia, which can survive for long periods (10-14 years). Nightshade and tomatoes are susceptible to the disease. The fungus can persist for some years in infected paddocks on these alternative hosts without showing symptoms. It is difficult to eradicate without fumigation.

Cultural Practices

- 1) Plant disease resistant varieties.
- 2) Do not plant in areas where other infected plants have grown.
- 3) Use crop rotation with cereals, grasses, and legumes.
- 4) Use chemical treatment of seed potatoes.
- 5) Control nightshade around the field perimeters.

Bacterial Soft Rot

Black Leg

(*Erwinia carotovora* var. *atroseptica*)

Bacterial soft rot and blackleg are principally caused by two varieties of the same species of bacterium (*Erwinia carotovora*) and are found wherever potatoes are grown. Black leg is a bacterial soft rot of the base of the stem. Symptoms on the plant include foliage with leaves that yellow then turn brown on the margins, curl upward and dies early. The base of the stem starts turning black and rotting with hollowing above the blackened area. As the disease progresses, the plant wilts and dies.

Bacterial soft rot affects tubers while in storage or in the soil before harvest. Seed tubers decay after planting. Areas of bacterial soft rot are cream to dark tan with a distinct, dark border between healthy and infected tissue. The rotted tissue is soft, mushy and can be easily be rinsed away with water. The bacteria is soilborne and spreads by contact. Soft rot is odorless in the early stages but develops a foul odor and slimy or ropey consistency as secondary organisms invade infected tissue. The primary source of soft rot is on seed potatoes. The bacteria can be spread through soil water, water used to wash tubers, bacteria entering lenticels, growth

cracks, or injuries at harvest time. The bacteria will survive in soils for a short time preferring cool, moist conditions as well as surviving in the tuber through the winter. Anaerobic conditions and high nitrogen fertilization increases susceptibility.

Control

The bacteria usually come from contaminated seed. Insects, rain splash, and equipment then spread it. Once a plant is infected, control is difficult, so prevention is usually best. Sometimes treatment with fixed copper fungicides can be effective.

Cultural Practices

Performing some cultural practices such as those listed below can help minimize infection. Reducing bruising of seed during handling is the most important consideration for reducing soft rot in the seed.

- 1) Control seed production; use only certified, disease free seed.
- 2) Treat and suberize seed pieces.
- 3) Warm seed.
- 4) Limit early nutrient supply to keep top growth within reason.
- 5) Have optimal drainage and aeration of the soil; avoid over-watering.
- 6) Harvest tubers when mature and at cooler temperatures.
- 7) Minimize mechanical damage.
- 8) Protect from solar irradiation and desiccation.
- 9) Cool to 50 degrees F or lower as soon as possible and store at temperatures as low as possible with good ventilation.
- 10) Avoid water films on tuber surfaces (condensation that results from placing tubers with low pulp temperatures into storage with relative humidity above 90%).
- 11) Do not wash tubers before storage and when washed dry them as soon as possible.
- 12) Use only clean water treated with chlorine to wash potatoes.
- 13) Practice good sanitation: Sterilize tools, sorting machinery, etc.
- 14) Remove affected plants from the field and burn them.

Fungicides - Foliar Sprays			
Contact the Montana Department of Agriculture for registration information			
Fungicide	Rate/A	Disease	Remarks
<i>Azoxystrobin</i>			

Quadris, 22.9%	6.2-15.4 fl oz	Late Blight, Early Blight	Spray or fungigation. Do not make more than 6 applications per acre per year for all diseases. Do not apply more than 2.88 qts product per acre per season. Do not apply within 14 days of harvest.
<i>Chlorothalonil</i>			
Bravo 500	1.0-2.13 pt	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 23 pints per acre during each growing season. Do not apply within 7 days of harvest. Do not exceed a 10-day interval between applications when using sprinkler equipment.
Bravo Ultrex DG, 82.5%	0.7-1.4 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 14.5 pounds per acre during each growing season. Do not apply with 7 days of harvest. Do not exceed a 10-day interval between applications.
Bravo Zn, 40.4%	1.0-2.13 pt	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 23 pints per acre during each growing season. Do not apply within 7 days of harvest. Do not exceed a 10-day interval between applications when using sprinkler irrigation.
<i>Copper</i>			
Basicop WP, 53%	3-6 lbs	Late Blight, Early Blight	Spray, Apply at first sign of disease and repeat 7 to 10 days thereafter.
Champ DP, 57.6%	0.66-2.66 lb	Late Blight, Early Blight	Spray or fungigation. Repeat treatment at 10 – 14 day intervals.
Champ Formula 2Flowable, 37.5%	0.66-2.66 pt	Late Blight, Early Blight	Spray or fungigation. Repeat treatment at 10 – 14 day intervals.
Kocide 2000, 53.8%	0.75-3.0 lb	Late Blight, Early Blight	Spray or fungigation. Apply at 7 to 10 day intervals.
Kocide 4.5 LF, 37.5%	0.66-2.66 pt	Late Blight, Early Blight	Spray or fungigation. Under conditions of severe disease, mix with other compatible fungicides registered for use on potatoes.
<i>Cymoxanil</i>			
Curzate 60 DF	3 1/3 oz	Late Blight	Spray or fungigation. Allow at least 14 days between vine kill and harvest in order to reduce spore load and minimize spore contact with tubers at harvest.
<i>Dimethomorph + Mancozeb</i>			
Acrobat MZ	2.25 lb	Late Blight	Spray or fungigation. Do not make more than 5 applications in any one season. Do not apply with 14 days of harvest.

<i>Iprodione</i>			
Rovral, 50% or Rovral 4 Flowable, 41.6%	1-2 lb 1-2 pt	Early Blight	Ground spray or fungigation. A maximum of 4 total applications per season. Do not apply with 14 days of harvest. Do not irrigate for 24 hours after application.
<i>Mancozeb</i>			
Dithane DFRainshield NT, 75%	0.5-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 15 lbs (11.2 lbs active ingredient) per acre per crop. Do not apply 14 days before harvest. The addition of a LATRON surfactant to spray solutions will improve performance.
Dithane F-45, 37%	0.4-1.6 qt	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 11.2 qts (11.2 lbs active) per acre per crop. Do not apply with 14 days of harvest.
Dithane M-45, 80%	0.5-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 14 lbs (11.2 lbs active) per acre per crop. Do not apply within 14 days of harvest.
Dithane WPS, 80%	0.5-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 14 lbs (11.2 lbs active) per acre per crop. Do not apply within 14 days of harvest. Vine-kill should occur 14 days before harvest. Recommended that this product be used in an IPM program. The addition of a LATRON surfactant to spray solutions will improve performance.
Gavel	1.5 to 2.0 lb	Late Blight, Early Blight	Spray or fungigation. Do not make more than 6 applications or apply more than 12 lbs per acre per crop. Do not apply within 14 days of harvest.
Manex II, 37%	0.8-1.6 qt	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 11.2 pounds (11.2 lb active) per acre per crop. Do not apply within 14 days of harvest. Vine-kill should occur 14 days before harvest. Recommended that this product be used in an IPM program.
Manzate 75 DF, 75%	1-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 15 pounds (11.2 lb per acre per crop. Do not apply within 14 days of harvest. Vine-kill should occur 14 days before harvest. Recommended that this product be used in an IPM program.

Penncozeb, 80WP or Penncozeb DF, 75%	0.5-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 15 pounds (11.2 lb per acre per crop. Do not apply within 14 days of harvest. Vine-kill should occur 14 days before harvest. Recommended that this product be used in an IPM program.
<i>Maneb</i>			
Maneb 80, 80% or Maneb 75DF, 75%	1.5-2 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 11.2 pounds (11.2 lb active) per acre per crop. Do not apply within 14 days of harvest. Vine-kill should occur 14 days before harvest. Recommended that this product be used in an IPM program.
Manex, 37%	0.8-1.6 qt	Late Blight, Early Blight	Spray or fungigation. Do not apply within 14 days of harvest, use with IPM program. Vine kill should occur 14 days before harvest
<i>Maneb + Triphenyltin Hydroxide (TPTH)</i>			
Pro-TeX, 32.63%:4.72%	0.75-1.5 qt	Late Blight, Early Blight	Spray or fungigation
Blite-Out Plus, 32.63%:4.72%	0.75-1.5 qt	Late Blight, Early Blight	Spray
<i>Metalaxyl + Chlorothalonil</i>			
Ridomil Gold/Bravo 76 WP,4.5%:72%	2 lb	Late Blight, Early Blight, Pythium Leak, Pink Rot	Spray or fungigation. Do not apply more than 3 applications at 14 day intervals. Recommended that this product be used within an IPM program. Vine-kill should occur 14 days before harvest
Ridomil Gold/Bravo Liquid Twin Pak	5 acre Pks 2 lbs	Late Blight, Early Blight, Pythium Leak, Pink Rot	Spray or fungigation. Do not apply more than 3 applications at 14 days intervals. Recommended that this product be used within an IPM program. Vine-kill should occur 14 days before harvest
<i>Metalaxyl + Copper Hydroxide</i>			
Ridomil Gold/Copper 65 WP, 5%:60%	2.0 lb + 0.5 lb ai of maneb, mancozeb, metiram or chlorothalonil	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 3 applications at 14-day intervals.

Ridomil Gold/Copper 65 WP, 5%:60%	2.0 lbs/acre	Pythium Leak, Pink Rot	Spray or fungigation. Do not apply with 14 days of harvest. Do not apply more than 3 applications per crop. Do not apply with 14 days of harvest.
<i>Metalaxyl + Mancozeb</i>			
Ridomil Gold MZ	2.5 lb	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 3 applications at 14-day intervals. Do not apply with 14 days of harvest. Do not apply more than 3 applications per crop.
<i>Metiram</i>			
Polyram 80 DF	1.5 - 2 lb	Pythium Leak, Pink Rot	Spray or fungigation. Recommended to be used with an IPM program Vine Kill should occur 14 days before harvest. Do not apply within 14 days of harvest, do not apply more than 14 pounds/acre per crop. No not use for livestock feed. Restricted Entry Interval – 24 hours
<i>Propamocarb</i>			
Previcur	1.2 pt	Late Blight, Early Blight	Spray or fungigation. Do not apply more than 6.0 pts in a single growing season. Do not apply within 14 days before harvest.
<i>Propamocarb + chlorothalonil</i>			
Tattoo C	2.3 pt	Late Blight, Early Blight	Spray or fungigation
<i>Triphenyltin hydroxide (TPTH)</i>			
Super Tin 80WP, AgPak, Agri Tin	1.5 -3.75 fl oz	Late Blight, Early Blight	Spray or fumigation- RESTRICTED USE PESTICIDE , Do not treat within 7 days of harvest. Do not exceed 11.25 ounces per acre per season.
Spray = ground or aerial, Fungigation = application through sprinkler irrigation system. ² Dosage = Amount of formulated product to apply. Label information from Greenbook and Crop Data			

Contact the Montana Department of Agriculture for registration information

Fungicides – Seed Treatments			
Fungicide	Rate	Disease	Remarks

<i>Pseudomonas syringae</i> (formulated bacterium)			
BIO-SAVE 110 and 1000BIO-SAVE 110 and 1000	500 gram/ 80 gallons water/ 1-2 tons	Fusarium dry rot and silver scurf	DO NOT use a quaternary ammonium compound since this will leave a residue that will kill the active bacterium. Clean the application system after each use with 30% isopropyl alcohol.
<i>Fludioxonil</i>			
Maxim II	0.5 lb / 100 lbs of seed pieces	Fusarium dry rot, Rhizoctonia solani (stem canker & tuber black scurf) and silver scurf.	Do not use treated seed pieces for food or feed purposes. Apply only with adequate ventilation. DO NOT USE ON SEED TO BE PLANTED FOR THE PRODUCTION OF SEED
<i>Fludioxonil + mancozeb</i>			
Maxim MZ	0.5 lb / 100 lbs of seed pieces.	Fusarium dry rot, Rhizoctonia solani (stem canker & tuber black scurf) and silver scurf.	Do not use treated seed pieces for food or feed purposes. Apply only with adequate ventilation. RECOMMENDED FOR USE IN SEED POTATO PRODUCTION
<i>Mancozeb</i>			
Dithane DFRainshield NT, 75	1¼ lb/50 gallons waterDo not apply within 5 days of harvest.	Fusarium Decay, Late Blight, Seedborne Common Scab, Rhizoctonia shoot blight, silver scurf	Do not use treated seed potatoes for food or feed purposes.
Dithane F-45 Flowable Seed Treat	1 qt/1 gal water	Fusarium Decay, Late Blight, Seedborne Common Scab, Rhizoctonia shoot blight, silver scurf	Do not use treated seed potatoes for food or feed purposes.
Dithane WPS	1¼ lb/50 gal water	Fusarium Decay, Late Blight, Seedborne Common Scab, Rhizoctonia shoot blight, silver scurf	Do not use treated seed potatoes for food or feed purposes.

Penncozeb DF or Penncozeb 80WP	1¼ lb/50 gal water	Fusarium Decay, Seedborne Common Scab	Do not use treated seed potatoes for food or feed purposes.
Maneb			
Manex Seed Treat or Manex II Seed Treat	1/50 gal	Fusarium decay, common scab	Do not use treated seed potatoes for food or feed purposes
Maneb 80WB or Maneb 75DF	1.0 lb/10 gal water	Fusarium decay, common scab	Do not use treated seed pieces for food, feed, or oil purposes.
Thiabendazole			
Mertect 340-F	0.42 fl oz per 2000 lbs	Fusarium tuber rot	Do not treat seed potatoes after cutting.

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Fungicides – Soil Treatment			
Fungicide	Rate	Disease	Remarks
<i>Pentachloro- nitrobenzene (PCNB)</i>			
Blocker	5.2-10.4 fl. oz./ 1000 ft of row	Stem Canker/Black Scurf (Rhizoctonia solani)	Do not exceed 20 lbs. Of actual PCNB per acre in any one season regardless of the method of application or formulation used.
<i>Mefenoxam</i>			
Ridomil Gold EC	0.42 oz/1000 linear ft on 6"-8" band at planting in minimum of 3 gal water/acr	Post harvest control of Pythium leak, pink rot, and seedling disease caused by Pythium spp.	Restricted entry interval 48 hours. Do not use the "dribble" application method with Admire. Apply mixture through approved pumping systems only. Do not combine with other chemistry or modify application directions. Do not apply to potatoes beyond the at-planting growth stage.

Ultra Flourish 25.1%	11.5 fl oz/ acre to 12 fl oz per acre dependent on row spacing	Post harvest control of Pythium leak, pink rot, and seedling disease caused by Pythium spp.	Restricted entry interval 48 hours. Do not use the “dribble” application method with Admire. Apply mixture through approved pumping systems only. Do not combine with other chemistry or modify application directions. Do not apply to potatoes beyond the at-planting growth stage.
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Contact the Montana Department of Agriculture for registration information

Weeds

Weeds are considered one of the three most serious problems associated with seed potato production. However, with proper preventative practices the impact of weeds on a crop is minimal. A reduction of crop yields can be directly related to competition between weeds and potatoes for nutrients and water. Weeds such as sunflower or mustard, attract aphids and other insects which impact the crops, and quackgrasses physically damage the tubers.

Weeds are divided into two groups, monocots (grasses) or dicots (broadleaf). Within these two groups plants can be either annual, biannual, or perennial. Control of weeds requires a combination of crop rotation, cultivation, herbicides, or a combination of all three. Cultivation before planting and during the hilling process will reduce weed establishment. Application of specific herbicides before planting, before plant emergence, and after plant emergence provides excellent weed control. A typical routine of herbicide application would be before planting to kill grassy and broadleaf weeds then just before or at plant emergence apply the herbicide again. A producer may also wait until after emergence and apply a combination of herbicides.

Mustards

The mustard family (*Brassicaceae*) is widely distributed throughout the cooler regions of the United States found along roadsides, cultivated fields, or any disturbed site. The mustard can be both annual and perennial, with watery, acrid juices. The leaves are usually alternate and simple. Wild Mustard, black mustard, and birdsrape mustard are a few of the more commonly called mustard plants. All three were introduced from Europe, have yellow flowers, grow from 1 to 4 feet tall or taller, and the seed pods have a constricted beak above the upper most seed.

Sunflowers

The sunflower is a member of the *Asteraceae* family, native to North America. It is an annual plant found along roadways, fence rows, or any disturbed site. The Common Sunflower can grow from 1 to 10 feet tall, with erect stems that may be branched. The leaves and stems are covered with short, coarse hairs that give them a rough texture. The leaves are simple, typically oval or heart shaped. The flower has bright yellow petals with a brown

disk center. The Nuttall Sunflower grows from 2 to 20 feet tall, with rough or smooth stems and oval to lanceolate leaves. The flowers are much smaller than the Common Sunflower, but also have bright yellow petals with a brown disk center.

Nightshades

The nightshade is a member of the *Solanaceae* family. Silver nightshade (*Solanum elaeagnifolium*), black nightshade, (*S. nigrum*) and hairy nightshade (*S. sarrachoides*) are not native to Montana and present particular problems for the potato producer. The potato is also a member of the *Solanaceae* family. Insects that are attracted to the nightshade are also attracted to potatoes, the most significant being the aphid. Controlling nightshade with herbicides require special care because of the impact it has on the potato plant.

Silver nightshade is found on rangelands, pastures, cropland, and disturbed areas. This plant is a perennial, spreading by rhizomes or seeds. The plant gets its name from the thick, short hairs that cover the stems and leaves. The leaves are lance shaped and the purple to light blue, star-shaped flowers are similar to the potato. This plant is poisonous to livestock.

Black nightshade and hairy nightshade is found in cultivated fields and disturbed areas. These plants are annual growing 6 to 24 inches tall. The black night shade has ovate leaves that taper to the tip and the hairy nightshade has arrow-headed shaped leaves that may feel sticky to the touch. The flowers on both species are , white to pale blue, and resemble that of the potato plant. The green fruit and foliage are toxic.

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Herbicide	Rate	Weeds	When to Apply	Remarks
Dual II (7.8EC) and Dual MAGNUM (7.62EC) (7.64EC) (<i>metolchlor</i>) (<i>s-</i> <i>metolchlor</i>)	2 to 3 pts/A 7.8EC 1 to 2 pts/A Magnums	Grass and some broadleaf	Pre-plant incorporated, pre-emergence, or after hilling/lay-by	Will not control emerged weeds

Dual II (7.8ED), and Dual MAGNUM (7.62EC) (7.64EC) + Sencor (75DF, 4F, 75 Solupak) or Lexone (75DF) (metribuzin)	2 to 3 pts/A of 7.8EC or 1 to 2 pts/A MAGNUM plus 0.75 to 2 pts/A Sencor or Lexone 4F	Grass and some broadleaf	After planting but before potatoes emerge	Do not mechanically incorporate. No effective on emerged weeds. Some potato varieties sensitive causing serious injury
Eptam (7EC) (EPTC)	3.4 to 7.0 pts/A	Grass and some broadleaf	Preplant, drag-off, hilling, and Lay-by	Must be thoroughly incorporated into soil. Not effective on emerged weeds
Eptam + Sencor (75DF,4D,75 Solupak)or Lexone (75DF) metribuzin	3.5 to 4.5 pts/A Eptam + 0.5 to 1 pts/A Sencor or Lexone 4F	Grass and some broadleaf	Preplant, during or after hilling, or through irrigation until potatoes 4-6" tall.	Musts be thoroughly incorporated. For postemergence use only on white-skinned varieties that are not early maturing. Some varieties sensitive causing serious injury.
Matrix (75DF) (rimsulfuron)	1 to 1.5 oz product/A	Grass and some broadleaf	Pre-emergence or postemergence when weeds are small	Hairy nightshade control only on seedlings. Always use with surfactant. Follow application by 0.5 to 1.75 inches of rainfall or sprinkler irrigation with 3-5 days after application. Should be tank mixed with Dual, Eptam, Sencor, or Prowl for preemergence applications.
Poast (1.5ED) (sethoxydim)	0.5 to 2.5 pts/A	Annual or perennial grasses	Apply to actively growing grasses. See label.	Will not control annual bluegrasses or fine fescues, weak on downy brome or quackgrass. Do not apply if rain expected.

Prowl (3.3EC) (pendimethalin)	1.8 to 3.6 pts/A	Grass and some broadleaf	Apply after planting up to 6 inch stage of potato growth	Will not control established weeds. Incorporate mechanically or through spinkler systems. Frontier Russet may be sensitive to Prowl.
Prowl (3.3EC) (pendimethalin) + Eptam (7EC) EPTC	1.2 to 3.6 pts/A Prowl + 3.0 to 3.4 pts/A Eptam	Grass and some broadleaf	Apply and incorporate after planting but before potatoes and weeds emerge. Apply through sprinkler system up to 6” after potato emergence.	Will not control established weeds. Do not apply if potatoes under stress from cold/wet or hot/dry. Do not apply within 24 hrs of other pesticides
Prowl (3.3EC) (pendimethalin) + Sencor (75DF,4F,75 Solupak) or Lexone (75DF) metribuzin	1.2 to 3.6 pts/A Prowl + 0.5 to 2 pts/A Sencor/ Lexone 4F	Grass and some broadleaf	Apply as tank-mix after planting up to the 6 inch stage of potato growth	Consult product labels. For optimum control apply before weeds are 1 one tall. May be applied through sprinklers.
Roundup Ultra Roundup Ultra RT (3WS) Glyphosate	0.75 to 4 pts/A	Grass and broadleaf	Apply after weed emergence but before potato emergence	See label for specific instructions. May add ammonium sulfate to enhance week control. Has no soil residual activity.
Sencor (75DF,4F,75 Solupak) or Lexone (75DF) metribuzin	1 to 2 pts/A PRE-EMERGENCE	Annual broadleaf and some grasses	Apply after planting or drag-off but before plant emergence.	Do not mechanically incorporate into the soil. Some potato varieties may be sensitive. Do not apply to potatoes growing under stress. Do not apply within 24 hours of application of pesticides.

Sencor (75DF,4F,75 Solupak) or Lexone (75DF) <i>metribuzin</i>	0.5 to 1 pt/ APOST- EMERGENCE Do not exceed 1 lb a.i./A	Annual broadleaf and some grasses	Apply before weeds are 1 inch tall	Crop injury may occur at higher rates. Lambsquarters and pigweed can be controlled with 0.5 pt/ A. Can be applied with Eptam, Prowl, Poast for enhanced grass control. Do not sprinkle within 24 hours of application. Can be applied through sprinkler system but do not mechanically cultivate. Some varieties may be sensitive, causing severe crop damage. Do not apply within 24 hours of pesticides.
Treflan (4EC) <i>(trifluralin)</i>	1 to 2 pts/A	Grass and some broadleaf	Apply after plantings, before emergence, immediately after drag- off or after fully emerged potato plants.	Mechanically incorporate within 24 hours of application. Does not control established weeds. Strict adherence to label rates and precautions must be observed. Do not plant any crops within 18 months if land fallowed without irrigation or cultivation.
Treflan (4EC) <i>(trifluralin)</i> + Eptam (7EC) <i>EPTC</i>	1 TO 1.5 PTS/a Treflan + 3.4 pts/ A Eptam	Grass and some broadleaf	Apply and immediately incorporate before potato and weed emergency or immediately following drag-off.	Do not use foliage from treated crops for fee

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Potato Vine Removal

At the end of the growing season, approximately the first of September, a defoliant is used to kill the vines. Vines are sprayed approximately three weeks before harvest. The vines remain on the field providing some protection against frost bite before the potatoes are harvested. Killing the vines allows the stolens to loosen from the tubers, hastens tuber maturity, and sets skin. The “skin set” trigger is the vine kill process. It takes about 18 – 21 days for tubers to completely heal after the skin set process has started. A tough, fully mature skin provides excellent disease and bruise protection. The tough skin is also crucial to providing a quality crop during harvesting and storage. Tuber maturity reduces water loss during storage, increases resistance to scuffing, decreases storage decay, and increases resistance to bruising during harvest and handling. Because of the short growing season in Montana, vine removal requires the use of chemical desiccants or mechanical vine choppers to aid in harvest before freezing temperatures damage tubers in the soil.

Mechanical vine choppers chop the green vines close to the surface, leaving the chopped vines in the field.

Mechanical vine chopping is considered more economical than chemical application.

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Chemical Dessicants	Rate	When to Apply	Remarks
<i>Endothall</i>			
Des-I-Cate (0.52S)	1.5 to 2 gal/A.	Apply 10 – 14 days before harvest	Use higher rate during cool or cloudy weather
<i>Paraquat</i>			
Gramoxone Extra (2.5S)	13 to 24 fl oz/A on fresh market potatoes only	Minimum preharvest interval is 3 days	RESTRICTED USE HERBICIDE. DO NOT USE ON POTATOES GOING INTO STORAGE.
<i>Diquat</i>			
Reglone (2SC)	1 to 2 pts/A	Apply last application at least 7 days before harvest	Protective gear should be worn for handling and application. Moderately toxic.
<i>Glufosinate-ammonium</i>			
Rely	3 pts/A	Apply 14 – 21 days before harvest	DO NOT APPLY TO POTATOES GROWN FOR SEED.
Sulfuric acid (93%)	17 to 25 gal/A	Apply 2 – 3 weeks before harvest	Very caustic. Protective clothing required including face shield, rubber boots, and rubber gloves must be worn.

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Internet Resources

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Insecticides registered in Potatoes in the Northwest - <http://ipm-dd.orst.edu/potato/insecticides.htm>
Derocerus Slugs - http://ipmwww.ncsu.edu/INSECT_ID/AG136/slug3.html
Management of Insect Pests & Beneficial Insects in Potato (OR) <http://ippc2.orst.edu/potato/links.htm>
Molcho Center - <http://molcho.org.il/>
Montana Pesticide Education Program - <http://mtpesticides.org/>
Colorado Crop Profile - <http://pestdata.ncsu.edu/cropprofiles/docs/copotatoes.html>
Idaho Crop Profile - <http://pestdata.ncsu.edu/cropprofiles/docs/IDpotatoes.html>
North Dakota Crop Profile - <http://pestdata.ncsu.edu/cropprofiles/docs/Ndpotatoes.html>
Encyloweedea (California) - <http://pi.cdfa.ca.gov/weedinfo/>
Montana Section 18 Status - <http://scarab.msu.montana.edu/extension/MTCurrent18.htm>
Potato Diseases (Montana) - <http://scarab.msu.montana.edu/extension/disea019.htm>
Montana State University IPM - <http://scarab.msu.montana.edu/ipm/>
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Greenhouse IPM: Sustainable Aphid Control - <http://www.attra.org/attra-pub/gh-aphid.html>
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Crop Data Management Systems - <http://www.cdms.net/manuf/products.asp>
Vegetable Insect Pest Management (NC) - <http://www.ces.ncsu.edu/depts/ent/notes/Vegetables/veg3.html>
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The Greenbook (Pesticide Labels) - <http://www.greenbook.net>
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MAES Research Benefits - <http://www.montana.edu/agriculture/Station/Benefits/PastProjects.html>
Herbicide Resistance in Montana Weeds - <http://www.montana.edu/wwwpb/ag/herbres.html>
Mother Earth News - <http://www.motherearthnews.com/>
Green Peach Aphid (Michigan) - <http://www.msue.msu.edu/vanburen/fgpa.htm>
Montana Agricultural Statistics Service - <http://www.nass.usda.gov/mt/>
Early Blight (NDSU) - http://www.ndsu.nodak.edu/instruct/gudmesta/lateblight/basic_frame3.htm

Late Blight (NDSU) - <http://www.ndsu.nodak.edu/instruct/gudmesta/lateblight/necrosis.html>

APS Diseases of the Potato - <http://www.scisoc.org/resource/common/names/potato.htm>

Potato Net Necrosis (Idaho) - <http://www.uidaho.edu/ag/plantdisease/pnniap.htm#>

Brown/Thomas Annual Report - <http://www.usda.prosser.wsu.edu/brown-thomas.htm>

WSU "Aphids on Potatoes" Hotline <http://www.wsu.edu/~potatoes/certified.htm>

Personal Interviews

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