Crop Profile: Potatoes in New York

Introduction: Potatoes are a vegetable crop of great economic importance in New York, and rank number one in economic value among vegetables produced in the state. Grown in several major production areas across the state, potatoes are used for fresh market (tablestock), processing (primarily chipping) and for seed. Of the wide variety of pests attacking potatoes, Colorado potato beetles and late blight disease are the most important. Imidacloprid is currently quite effective, but Colorado potato beetles have shown a remarkable ability to develop resistance. The industry needs to have a variety of insecticides of differing modes of action, including some organophosphates as well as new materials, in order to manage resistance in this pest. Metalaxyl-resistant strains of the late blight pathogen have become widespread in the US, greatly increasing the relative importance of this potentially devastating disease. Because no curative systemic fungicide is available to control late blight outbreaks, use of protectant fungicides has increased significantly over the past five years. The industry has critical needs for: new insecticides for CPB control; a curative systemic fungicide for late blight control; and registration of new herbicides for weed control. Without the registration of new effective alternatives, the loss of methamidophos, dimethoate, the EBDC fungicides, chlorothalonil, metolachlor, linuron, metribuzin, CIPC, or maleic hydrazide would have significant impacts on production and profitability. Between the increased costs of late blight control and strong competition for markets from Canadian producers, growers are already struggling to keep their operations profitable.

Registration of new materials by the EPA, even those designated as "low risk", does not guarantee that NY growers will have immediate access to them. NYS Department of Environmental Conservation conducts their own in-depth reviews before registering new pesticides in NY, and may or may not register new materials for portions of or for the entire state.

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II. Basic Commodity Information

State Rank: 12th
% U.S. Production: 1.7%
Acres Planted: 27,600
Acres Harvested: 27,000
Cash Value: $63,000,000
Yearly Production Costs: $1300-1800, estimated

Production Regions: Potatoes are grown in most of the vegetable production regions of the state. Areas with significant production include Long Island (Suffolk County), northern NY (Franklin County), central New York (Oswego, 386; Steuben, Wayne, Ontario, Oneida, and Livingston counties), and western NY (Erie, Genesee, Monroe, Orleans, and Wyoming counties).

Cultural Practices: Potatoes are produced in New York for fresh market (tablestock), processing (primarily chipping) and for seed. The predominant type produced is the Eastern round white, although red-skinned varieties, yellow-fleshed varieties, and a limited amount of russets are produced as well. New York potatoes and potato products are primarily consumed locally and within the northeastern region.

Potatoes are propagated asexually, from cut pieces of potato tubers. New York producers purchase their seed potatoes primarily from certified suppliers within the state as well as from Maine and the mid-West. Careful controls on seed potato production help minimize seed-borne diseases. Seed potatoes are delivered as whole tubers, and growers generally cut them up, treat the pieces with fungicides, and cure them for several days before planting. Planting starts as early as April in warmer areas, and continues through May and early June. Potatoes are planting on both muck (high organic matter soils) and mineral soils. Row spacing is typically 34 or 36 inches, and seed pieces are placed 6-12 inches apart in the row. Typically 1000-3000 lbs of seed potatoes are planted per acre, depending on seed piece size, row spacing, and spacing between plants.

Fertility levels are carefully managed to maximize crop yield as well as quality. Potatoes are almost always cultivated, not only to control weeds, but to deeply cover tubers ("hilling") in order to prevent greening. Irrigation is being increasingly used to manage water during dry periods of the growing season.

Potato harvesting starts as early as July for some fresh market crops, but most are harvested between late August and October. Chemical vine killing is used to aid harvest by desiccating vines and weeds and conditioning the tubers to reduce bruising and skinning during harvest and handling. Vine killing also controls tuber size, minimizes the incidence of hollow heart, and helps control diseases such as late blight and leafroll. Under good conditions, the time between vine killing and harvest is 10-14 days. A large proportion of the New York potato crop (tablestock and chipstock) is placed in storage for shipment through the winter and spring. These potatoes may be treated with sprout inhibitors in the field or in storage to lengthen the natural period of dormancy, and are sometimes washed before being placed in storage. For the first two to three weeks in storage, tubers are held at high relative humidity and 50-60^{o}F to cure. Temperatures are then slowly lowered to 40^{o}F for tablestock or seed and 45-50^{o}F for chipping potatoes. Most storages use a forced-air system for ventilation and temperature control. In general, producers have decided if a crop will go for fresh market or processing before the crop is planted, but there is some flexibility on final destination after harvest.

Commodity Destination(s):

Tablestock: 55%
Chipping: 40%
Seed: 5%

III. Pest Information: Insects

1. Colorado Potato Beetle *(Leptinotarsa decimlineata)*

Frequency of Occurrence: Annually. Several years of widespread use of imidocloprid have reduced populations considerably.

Damage Caused: Colorado potato beetle adults and larvae feed on leaves and stems. Damage can be extensive enough to cause plant death, and less severe infestations can weaken plants and cause decreases in yields.

% Acres Affected: 100%

Pest Life Cycles: Colorado potato beetles overwinter in soil in fields and field borders. They emerge in spring and begin feeding on potatoes, mating and laying bright orange eggs. Nightshade and horse nettle are also hosts. Larvae also feed on foliage. They may have one to three generations per year in NY, depending on the length of the season. In mid-August, most egg laying ceases and adults begin to enter the soil for overwintering.

Timing of Control: All season, but especially when plants are small.

Yield Losses: Up to 100% in severely infested fields; currently typical losses are 1-10%.

Regional Differences: Pressure and resistance problems are greater on Long Island than in upstate NY.

Cultural Control Practices: In response to CPB's phenomenal ability to develop resistance to insecticides, a number of cultural control practices have been developed as part of an IPM approach. These cultural practices usually focus on controlling the overwintering population, and include: crop rotation, site selection, propane flaming, trap cropping, use of trench traps. For more detailed information on these practices, see Reference #2. Except for cases of small scale planting with excellent rotations, cultural practices alone do not provide commercially acceptable levels of control.

Biological Control Practices: Naturally-occurring predators, parasitoids, and pathogens help suppress infestations, but information on their efficacy is lacking.

Post-Harvest Control Practices: Flooding (which occurs naturally on many muck fields) can reduce overwintering populations.

Other Issues: Research on CPB control in potatoes is ongoing (Tingey), and focuses on screening new materials for efficacy, and on managing resistance to new materials.

Insecticides for Foliar Insect Control in Potatoes:

Pesticide	Target Pest[1]	% Trt.	Type of Appl.	Typical Rates, lbs ai/acre	Timing	# of Appl.	PHI[2] days	REI hours
abamectin[3] *(Agri-Mek)*	CPB	15	foliar, ground or air	0.009	as needed during season	1-2	14	12
azadirachtin *(Neem)*	CPB	<1	foliar, ground or air	0.01-0.033	as needed during season	--	14	12
azinphos-methyl *(Guthion)*	CPB, PLH, FB, ECB	2-3	foliar, ground or air	0.375	as needed during season	1	28	72
Bts *(several)*	CPB	2-3	foliar, ground or air	varies w/ formulation	as needed during season	1-3	30	0
carbofuran[4] *(Furadan)*	CPB, PLH, FB, ECB	1-2	foliar, ground or air	1.0	as needed during season	1	14	48
cryolite[5] *(Kryocide)*	CPB	10	foliar, ground or air	10-12	as needed during season	1-2	14	12
endosulfan[6] *(Thiodan)*	CPB, PLH, FB	15	foliar, ground or air	0.75	as needed during season	1-3	7	24
esfenvalerate[7,8] *(Asana)*	CPB, A, PLH, FB, CW, ECB	10	foliar, ground or air	0.036	as needed during season	1	25	12
imidacloprid[9] *(Admire)*	CPB	45	soil; direct spray on seed pieces	0.23	at planting	1	90	12
imidacloprid[10] *(Provado)*	CPB, A	55	foliar, ground or air	0.05	as needed during season	1-3	30	12
oxamyl[4] *(Vydate)*	CPB, A, PLH, FB	10	foliar, ground or air	0.75	as needed during season	1-2	14	48
permethrin[7] *(Ambush)*	CPB, PLH, FB, CW, ECB	5	foliar, ground or air	0.15	as needed during season	1-2	25	12
phosmet[4] *(Imidan)*	CPB, PLH, FB	3	foliar, ground or air	0.9	as needed during season	1	28	24
rotenone[7] *(Rotenox)*	CPB	<1	foliar, ground or air	0.25	as needed during season	1	14	--
methamidophos *(Monitor)*	A, PLH, FB, CW, ECB	95	foliar, ground or air	0.5[12]-0.75	as needed during season	1-3	14	48
methomyl *(Lannate)*	A, PLH, FB, CW	<1	foliar, ground or air	0.9	as needed during season	1	14	48
disulfoton[4] *(Di-Syston)*	A, PLH, FB	10	soil; in furrow	3.0	at planting	1	90	48
dimethoate[11] *(Dimethoate)*	A, PLH	50	foliar, ground or air	0.5	as needed during season	1-3	21	48
carbaryl *(Sevin)*	PLH, FB, CW	<1	foliar, ground or air	1.0	as needed during season	1	28	12
methyl parathion *(Penncap-M)*	PLH, FB, ECB	<1	foliar, ground or air	1.5	as needed during season	1	14	48
phorate *(Thimet)*	PLH, FB	1-2	soil; in furrow	3.0	at planting	1	90	48

1. Key to target pests: CPB=Colorado potato beetle; A=aphids; CW=cutworms; ECB=European corn borer; FB=flea beetle; PLH=potato leaf hopper.
2. PHIs in this and all tables indicate shortest actual number of days between application and harvest, not label PHIs.
3. Abamectin is used on approximately 50% of potato acres on Long Island, and on <1% in upstate NY. Rates will probably decrease to 0.007 lbs ai/acre in 1999 due to a 2(ee) label.
4. Not used on Long Island.
5. Cryolite is used on approximately 30% of potato acres on Long Island, but on <1% in upstate NY.
6. Endosulfan is used on approximately 15-20% of potato acres in upstate NY, and on approximately 5% on Long Island.
7. For CPB control, piperonyl butoxide is added to these insecticides.
8. Esfenvalerate is used on approximately 10-15% of potato acres in upstate NY, and on 1-3% on Long Island.

9. Soil applications of imidacloprid are used on approximately 95% of potato acres on Long Island and 15% in upstate NY.
10. Foliar applications of imidacloprid are ued on approximately 75% of potato acres in upstate NY, and on 60% on Long Island.
11. Dimethoate is used on approximately 80% of upstate NY potato acreage, and on <1% on Long Island.
12. 2(ee) recommendation based on efficacy data. The lower rate is very effective against leafhoppers and controls most aphids without strongly selecting for resistance in either aphids or CPB.

Use in IPM Programs: As-needed use of effective insecticides is consistent with Cornell IPM recommendations. These recommendations call for rotational use of insecticides (differentially targeting specific generations), as well as the use of cultural control practices for resistance management. A procedure for scouting CPB and economic thresholds have been established. For details, see Ref. #2.

Use in Resistance Management Programs: Given the phenomenal ability of the CPB to develop resistance to insecticides, a major goal in managing this pest is to delay the onset of resistance. Because of this, it is essential to have a variety of insecticides of differing modes of action in the "tool box". Even though CPB has shown resistance problems to many OPs, it could be useful to retain registrations of some of these (e.g. azinphos-methyl, phosmet, phorate, oxymyl) for use in resistance management, as well as for control of other insects. CPB may already be developing some resistance to imidacloprid on Long Island.

Efficacy Issues: A number of the insecticides listed above result in variable control of CPB because of resistance problems, including azinphos-methyl, carbofuran, endosulfan, oxamyl, permethrin, phorate, phosmet, and rotenone. Control can sometimes be achieved if these are used in combination. Several insecticides (abamectin, azadirachtin, Bts, cryolite, rotenone) may be effective on larvae but not on adults. Under field conditions, either adults and larvae, or only adults are typically present. Imidacloprid is currently very effective, but CPB could develop resistance to this material quickly. The use of triphenyltin hydroxide fungicides for late blight and early blight control may suppress CPB feeding and reduce egg laying and survival by limiting disease development.

Alternatives: NewLeaf varieties of potatoes, genetically engineered to express the Bt toxin gene, are a potential alternative, although yield and quality problems have been observed in these varieties in early trials. Widespread use could result in Bt-resistant CPB. Spintor (spinosad) may be an effective material, especially used in an IPM/resistance management program, but trials have yet to be conducted. Chloronicotinil, a new insecticide from Novartis, may be effective against CPB, although there may be cross-resistance problem with imidacloprid.

2. Aphids *(several species)*

Frequency of Occurrence: Annually.

Damage Caused: Aphids injure plants by feeding on plant juices and by transmitting viruses. Injury from feeding by green peach aphids is often subtle and seldom reflected by obvious changes in plant growth or growth form. Frequently, growers become aware of a damaging aphid infestation because of premature death or early senescence of their crop. By this time, damage in the form of reduced yield is irreversible. Damage resulting from the transmission of viruses (such as rugose and potato leafroll viruses) is usually much more dramatic than direct feeding injury.

% Acres Affected: 100%

Pest Life Cycles: A number of aphid species infest potatoes in New York, including the green peach aphid (*Myzus persicae*), potato aphid (*Macrosiphum euphorbiae)*, melon aphid (*Aphis gossypii*), buckthorn aphis (*Aphidula rhamni*) and foxglove aphid (*Aulacorthum solani*). Aphids overwinter as eggs on a variety of crops and weeds. The eggs hatch in the spring, and after one or more generations on the overwintering host, winged aphids are produced and migrate to a variety of other hosts, including potatoes. Females can reproduce without mating with males. Each aphid can give birth to 50-100 live young, all females. There may be 5-10 generations per season. In the fall, a generation with winged males and females is produced. These migrate back to overwintering hosts, mate, and lay eggs.

Timing of Control: June through vine-kill

Yield Losses: Up to 75% in severely affected fields.

Regional Differences: None.

Cultural Control Practices: Avoid planting fields immediately downwind of any barrier. Hedgerows, wood lots, or hilly terrain reduce wind velocity and increase the number of dispersing aphids falling into fields. The use of reflective mulches or mineral sprays may limit virus transmissions by migrant aphids, but this is not practical for commercial scale plantings. Harvest the crop as early as possible to minimize vulnerability to late-season aphid colonizations and virus infection. Eliminate weeds in and around fields. Rogue volunteer plants and diseased plants. Some varieties are virus-resistant.

Biological Control Practices: Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Aphid populations may decline rapidly during periods of heavy rainfall.

Post-Harvest Control Practices: None.

Chemical Controls: See "Colorado Potato Beetle" section above for pesticide use information.

Use in IPM Programs: As-needed use of insecticides is consistent with Cornell IPM recommendations. Methods for monitoring and scouting for aphids, as well as economic thresholds, have been established.

Use in Resistance Management Programs: Although not confirmed, there have been some reports of aphids exhibiting resistance to methamidophos.

Efficacy Issues: Methamidophos is currently a critical insecticide for the control of aphids (green peach and potato aphids) and aphid-vectored viruses, particularly in seed potatoes. Loss of this insecticide before the registration of a new, effective material could have significant impacts on production and profitability. Imidacloprid is very effective tool in managing aphids, but over-reliance on imidacloprid for aphid control could hasten resistance in CPB. Disulfoton is less effective on muck than on mineral soils.

Alternatives: Pymetrozine (trade name Fulfil), a new insecticide from Novartis, is a potential alternative, and results from preliminary trials have been encouraging. EPA has fast-tracked registration of pymetrozine.

3. Cutworms *(several species)*

Frequency of Occurrence: Sporadic.

Damage Caused: Cutworms cause direct feeding damage to potato seedlings and mature plants, removing foliage, cutting the stems at soil level, or feeding on underground tissues.

% Acres Affected: 100% at risk of damage; typically 1-5% affected per year.

Pest Life Cycles: Many cutworm species attack potatoes, including the variegated cutworm (*Peridroma margaritosa*) as well as others. Cutworms overwinter either as large larvae or as eggs in the soil. They tend to be most abundant in weedy areas in a field or adjacent to cover crop strips after the cover crops are killed or tilled under. They pupate in the soil and adult moths emerge in June or July. They may have 1-3 generations per year.

Timing of Control: All season.

Yield Losses: Can be as high as 50% in severely affected fields. Typical losses are 1-5%.

Regional Differences: None.

Cultural Control Practices: None.

Biological Control Practices: Naturally-occuring predators, parasitoids, and pathogens may help suppress infestations.

Post-Harvest Control Practices: None.

Chemical Controls: See “Colorado Potato Beetle” section above for pesticide use information.

Use in IPM Programs: Methods for monitoring and scouting for cutworm activity, as well as thresholds, have been established. As-needed use of insecticides is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: As-needed use of insecticides is consistent with Cornell IPM recommendations.

Alternatives: Lambda-cyhalothrin is used for cutworm control in sweet corn, and could possibly be an alternative in potatoes as well.

4. European Corn Borer *(Ostrinia nubilalis)*

Frequency of Occurrence: Occasional.

Damage Caused: Although corn is the preferred host of European corn borer (ECB), the insect will attack potatoes and some other vegetable crops. Damage is caused by larval feeding in stems. Infested stems are weakened and are predisposed to wilting and breaking. Larval feeding may also predispose the plant to *Erwinia* infections (aerial blackleg). Survival and establishment of larvae vary depending on potato cultivar and field conditions. Damage seems to be increasing in recent years, possibly due to changes in insecticide use patterns with the advent of imidacloprid. Early planted potatoes which emerge before much corn has emerged is often the most susceptible to damage.

% Acres Affected: 100% at risk of infestation; typically up to 25% affected per year.

Pest Life Cycles: The ECB is a major pest of corn, and an occasional pest of potatoes, snap beans, and peppers. Corn borers overwinter as the last larval instar in the stalks and stems of corn. These pupate in late April and early May. Several strains exist in NY. Adults of the 2-generation strain first emerge in late May to early June and again in August. Adult emergence of the single generation strain peaks in July. Eggs are laid in masses primarily on the underside of leaves. Larvae hatch, feed for a short period on leaves, and then bore into stems.

Timing of Control: June and July.

Yield Losses: Up to 10% in severely infested fields.

Regional Differences: Pressure tends to be earlier and heavier on Long Island compared to upstate NY.

Cultural Control Practices: Plowing prior to moth emergence may kill overwintering larvae. Avoid planting potatoes in fields following corn. Mow grassy areas around fields to eliminate breeding areas. Use resistant varieties.

Biological Control Practices: Naturally occurring predators, parasitoids, and pathogens may help suppress infestations, but information is lacking.

Post-Harvest Control Practices: None.

Chemical Controls: See “Colorado Potato Beetle” section, above, for information on pesticide use patterns.

Use in IPM Programs: Methods for monitoring ECB activity in potatoes and other crops have been established. As-needed use of insecticides is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: None reported.

Alternatives: Spinosad may be an effective material for ECB control in potatoes, but trials have yet to be conducted.

5. Flea Beetles *(Epitrix cucumeris)*

Frequency of Occurrence: Occur at some population levels almost annually.
Damage Caused: Flea beetles feed directly on the foliage. Potatoes are most sensitive to damage when very small.
% Acres Affected: Up to 25% affected per year.
Pest Life Cycles: Adult flea beetles overwinter in the soil and emerge early in the spring to feed and lay eggs. Larvae feed on plant roots, but do not cause significant damage at this stage.
Timing of Control: May-July.
Yield Losses: Currently an area of dispute. Yield losses have not been documented by research.
Regional Differences: None.
Cultural Control Practices: One variety is resistant to flea beetles.
Biological Control Practices: Naturally occurring predators, parasitoids, and pathogens may help suppress infestations.
Post-Harvest Control Practices: None.
Chemical Controls: See "Colorado Potato Beetle" section, above, for information on pesticide use patterns.
Use in IPM Programs: Thresholds have not been established.
Use in Resistance Management Programs: None reported.

6. Potato Leafhopper *(Empoasca fabae)*

Frequency of Occurrence: Annually.
Damage Caused: The potato leafhopper (PLH) is a sucking insect, removing plant sap directly from the vascular system in the leaflet, petioles, and sometimes the stem. In the feeding process, PLH injects a salivary toxin that causes injury to the plant. PLH can stunt potato plants, and may even cause plant death in seedlings.
% Acres Affected: 100%
Pest Life Cycles: PLH does not overwinter in NY. Adults migrate in each year between April and June. The first migrants are primarily females, and over half of these have been fertilized prior to migration. The number of annual generations in northern states varies from 1-6. Eggs are laid singly within the petioles and veins on the under surface of foliage. Eggs hatch in ten days, and the nymph passes through five stages within a period of 12-35 days.
Timing of Control: Early June through August
Yield Losses: Can be up to 75% in severely infested fields.
Regional Differences: None.
Cultural Control Practices: Two varieties have some resistance to potato leafhopper, but these varieties are not acceptable to most markets.
Biological Control Practices: Although a variety of natural enemies of potato leafhopper have been reported, their impact on infestations is not well known.
Post-Harvest Control Practices: None.
Chemical Controls: See "Colorado Potato Beetle" section, above, for information on pesticide use patterns.
Use in IPM Programs: Methods of scouting for PLH, as well as economic thresholds, have been established. As-needed use of insecticides is consistent with Cornell IPM recommendations.
Use in Resistance Management Programs: None reported.
Efficacy Issues: Producers in upstate NY find that dimethoate is the most effective (and cost-effective) insecticide for controlling PLH. Producers in Long Island may be getting good control of PLH due to higher uses of imidacloprid. Use of azinphos-methyl and carbaryl may induce aphid outbreaks. Several available insecticides (esfenvalerate, methomyl, and permethrin), may not be compatible with triphenyltin hydroxide fungicides, commonly used on potatoes.
Alternatives: Unknown.

7. Wireworms *(several species)*

Frequency of Occurrence: Sporadic.
Damage Caused: Damage is caused by larval feeding on underground plant parts. Young larvae feed on root hairs and roots, and older larvae feed on tubers, seedpieces, and roots.
% Acres Affected: 100% of acres are at risk; typically 5-10% affected.
Pest Life Cycles: The adults are known as "click beetles" because of the structure on the ventral side with which they are able to

right themselves if inverted. Eggs are small, pearly white, and spherical. The newly hatched larva or wireworm is white, and less than 1/8th inch. Mature larvae range from 1/2 to 1 inch in length. It takes 4-5 years for the larvae to complete development. After a short pupation period adults emerge, usually in May or June, and lay eggs. Eggs hatch in approximately five weeks.

Timing of Control: June through September.

Yield Losses: Up to 50% in severely affected fields. Typical losses are 1-5%.

Regional Differences: None

Cultural Control Practices: Potatoes should not be planted in fields that have been in sod crops for the previous two years. In some cases, wireworm infestations may be initiated in wheat and small grain crops. In these cases, substitution of a row crop such as corn in the rotation is advisable. Avoid planting in poorly drained soils or wet areas. Keep land free of grassy weeds during the egg-laying period (May through late June) will greatly reduce the potential for infestation.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Insecticides for Soil Insect Control in Potatoes:

Pesticide	Target Pest[1]	% Trt.	Type of Appl.	Typical Rates, lbs ai/acre	Timing	# of Appl.	PHI days	REI hours
diazinon *(Diazinon)*	WW	<1	soil broadcast	4.0	before planting	1	90	24
ethoprop[2] *(Mocap)*	WW S	<1	soil	6.0	at planting	1	90	48
fonofos *(Dyfonate)*	WW S	1-2	soil broadcast	2.0	before planting	1	90	48

1. Key to pests: WW=wireworms; S=symphylans.
2. Not labeled for use on Long Island.

Use in IPM Programs: As-needed use of insecticides is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: None reported.

Efficacy Issues: Neither ethoprop or the registered alternatives provide satisfactory control under high wireworm populations.

Alternatives: Fipronil (trade name Agenda) may be a useful alternative in wireworm control, but trials have yet to be conducted.

8. Symphylans *(Scutigerella immaculata)*

Frequency of Occurrence: Sporadic.

Damage Caused: Symphylans cause damage to plants by direct feeding on underground tissues.

% Acres Affected: 5-10%

Pest Life Cycles: Symphylan adults, or centipedes, are white narrow-bodied creatures almost 1 cm in length with 12 pairs of short legs. Egg laying begins in the spring and continues throughout the summer. Masses containing up to 20 eggs are deposited, and hatching takes place in about 10 days. All life stages occur in the soil. The symphylans molt six times and are fully developed in 45-60 days. During very hot or cold weather, they migrate into the subsoil. Life span is said to be 4-5 years.

Timing of Control: May through July.

Yield Losses: Can be 5-10%??? in severely affected fields.

Regional Differences: Symphylans seem to be a problem mostly in the far western counties *(anyone know if they are a problem elsewhere?).*

Cultural Control Practices: Where practical, continuous submergence of fields under water for two weeks in summer and one month in winter will rid the soil of symphylans for two years.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See "Wireworms" section, above, for information on pesticide use patterns.

IV. Pest Information: Diseases and Nematodes

1. Seed Piece Decay and Seedborne Pathogens (several species)

Frequency of Occurrence: Sporadic.

Damage Caused: Potato seed pieces can become infected with fungal or bacterial pathogens causing decay. Yield loss is due to loss of plant stand.

% Acres Affected:100% at risk; typically 5-10% affected.

Pest Life Cycles: Seed pieces can become infected by *Fusarium, Rhizoctonia*, and *Streptomyces* spp. as well as by a range of bacterial soft rot pathogens. These pathogens may be soil-borne or may come in on the seed potatoes.

Timing of Control: Before planting.

Yield Losses: Can be up to 50% in severely affected fields due to stand loss.

Regional Differences: None.

Cultural Control Practices: Seed quality is the most important factor in minimizing losses. Seed treatment with fungicides is the second most important consideration. Seed should be warmed to 50^{O} F before handling, cutting, or planting. Seed planted into warm, well-drained soil will emerge faster, minimizing risk of loss. Shallow planting and light cultivation to break up compacted soil will increase soil temperature, improve oxygen levels around the seed piece, and speed plant growth. Physiological disorders due to lack of oxygen and cold temperatures during storage or in transit contribute to seed piece problems and poor stand establishment.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Fungicides for Seed Treatments:

Pesticide	Target Pest	% Trt.[1]	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI days	REI hours
maneb *(Maneb)*	Fusarium	50 U 70 LI	seed piece dip	0.75 lbs ai/10 gal water	before planting	1	100	24
thiophanate-methyl *(Tops 2.5D)*	Rhizoctonia, Fusarium	1-5, U & LI	seed piece dust	0.025 lbs ai/100 lbs seed	before planting	1	100	12
mancozeb *(Dithane)*	Rhizoctonia, Streptomyces, Fusarium	<1, U & LI	seed piece dip	0.75 lbs ai/50 gal water	before planting	1	100	24
captan *(Captan)*	Fusarium	60 U <1 LI	seed piece dust	0.75 lbs product/100 lbs seed	before planting	1	100	48
fludioxonil[2] *(Maxim)*	Rhizoctonia, Fusarium, Helmintho-sporium	5-10 U & LI	seed piece dust	0.025 lbs ai/100 lbs seed	before planting	1	100	12

1. U=upstate NY; LI=Long Island (Suffolk County)

2. New material; use is expected to increase in future. Not for use on potatoes grown for seed.

Use in IPM Programs: Use is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: A number of strains of Fusarium and Helminthosporium have become resistant to thiophanate-methyl, and use of this fungicide has decreased accordingly. Because of the concern of resistance development to fludioxonil, its use is limited to commercial (non-seed) production.

Efficacy Issues: Fludioxonil is not a systemic fungicide, and therefore is most effective in controlling diseases on the seed tuber. An added economic expense will occur with the loss of captan or maneb for seedpiece treatment.

Alternatives: None available at this time.

2. Late Blight *(Phytophthora infestans)*

Frequency of Occurrence: Late blight has been found in at least one potato growing region in New York every year since 1994.

Damage Caused: Late blight infections can devastate fields of both potatoes and tomatoes if not controlled. Under the right weather conditions, infections can spread extraordinarily rapidly. In potatoes, either foliage, tubers, or both may be infected. Infected tubers develop a shallow reddish-brown dry rot that invades the flesh of the tubers. Bacterial soft rot often follows. A distinctive foul, rotton odor is typical for fields killed by late blight. Potatoes grown for seed must have no more than 1% late blight tuber rot.

% Acres Affected: 100% at risk of infection; in past several years, late blight has affected 1-5% of the acres.

Pest Life Cycles: Spores of the late blight fungus are commonly carried by wind, rain, and equipment. They can travel up to 100 miles in the air. Lesions on infected leaves and stems become visisble as small flecks within three to five days after infection. The infected tissue is intially water-soaked but becomes brown or black in a few days. Under high humidity, sporulation is visible as a delicate white mold surrounding the lesions. In this white cottony mycelial growth, lemon-shaped structures called sporangia form on stalk-like sporangiophores. These sporangia produce and release motile zoospores under cool moist conditions. Rain may wash sporangia from blighted foliage down the stems to the tubers below, causing tuber infection. The late blight fungus overwinters in tubers in cull piles and in those left in the field. Young shoots from tubers in cull piles or in the field are produced early in the season. Late blight infections in these tubers provide initial inoculum for field infection. Infected seed potatoes also serve as an important source of inoculum. In recent years, several new strains of the pathogen have spread throughout the US, Mexico and Europe. These new strains are resistant to metalaxyl, previously an effective curative fungicide, so the disease has become of much greater economic significance than in the previous decade.

Timing of Control: Throughout the growing season and in storage.

Yield Losses: Up to 100% loss in the field or in storage.

Regional Differences: None.

Cultural Control Practices: Commercial varieties do not have useful levels of resistance. Proper hilling and vine-killing practices reduce the exposure of tubers to spores. Use of disease-free seed is important, but disease-free seed is not always available. Cull piles should be eliminated (buried or otherwise destroyed) before plants emerge in the spring. Foliage and vines should be completely dead and dry before harvest to avoid inoculating tubers. Crop rotation is not effective.

Biological Control Practices: None.

Post-Harvest Control Practices: Storages should be monitored for infection. If detected at low levels, decrease storage temperature immediately to as low as the market will allow and increase air flow to dry out tubers. If moderate levels are detected market the crop as soon as possible.

Other Issues: Research on late blight is ongoing (Fry), and focuses on screen fungicides for efficacy, need brief description of scope and objectives of this research. Because of the serious nature of this disease, and the lack of curative fungicides and subsequent reliance on protective fungicides, late blight management now drives fungicide use in potatoes. Fungicide use is up significanly since the arrival of metalaxyl-resistant late blight strains.

Foliar Fungicides for Potato Disease Control:

Pesticide	Target Disease[1]	% Trt.[2]	Type of Appl.	Typical Rates lbs ai/acre	Timing	# of Appl.[3]	PHI days	REI hours
maneb *(Maneb)*	EB, LB	50 U 40 LI	foliar; ground or air	1.5	as needed through season	2-7	7	24
chlorothalonil *(Bravo)*	EB, LB, WM	60 U 20 LI	foliar; ground or air	1.0	as needed through season	3-8	7	48
mancozeb *(Dithane)*	EB, LB	80 U 100 LI	foliar; ground or air	1.5	as needed through season	6-10	7	24
triphenyltin hydroxide *(SuperTin)*	EB, LB	50 U 5 LI	foliar; ground or air	0.15	as needed through season	2-5	21	48
copper compounds	EB, LB	60 U <1 LI	foliar; ground or air	varies with formualtion	as needed through season	2-3	7	24
iprodione *(Rovral)*	EB, WM	<1	foliar; ground or air	0.5-1.0	as needed through season	1	14	12
metiram *(Polyram)*	EB, LB	50 U 5 LI	foliar; ground or air	1.6	as needed through season	2-4	7	24
azoxystrobin[4] *(Quadris)*	EB, LB	pending	Foliar, ground or air	0.1-0.25	as needed through season	max. 6	14	4
cymoxanil[5] *(Curzate)*	LB	5-10 U <1 LI	foliar; ground or air	0.12 cymoxanil; 1.0 mancozeb	used when late blight is detected	2-3	14	?
propamocarb[5] *(Tattoo-C)*	LB	15 U 2 LI	foliar; ground or air	0.9 propamocarb; ? chlorothalonil	used when late blight is detected	1-2	7	?
dimethomorph[5] *(Acrobat)*	LB	1-3	foliar; ground or air	0.2 dimethomorph; 1.35 mancozeb	used when late blight is detected	1-2	7	?

1. EB=early blight; LB=Late blight; BVR=botrytis vine rot; WM=white mold.

2. U=upstate NY potato acres; LI=Long Island potato acres.

3. Which of the protectant fungicides (maneb, mancozeb, chlorothalonil, metiram) is used is a decision often driven by cost, as well as by EBDC yearly maximum rate allowances. For example, if metiram is less expensive than mancozeb, it will be used more frequently. There is significant variability from grower to grower in which fungicides are used and how frequently.

4. Pending for 1999. Not available for use in Long Island (Suffolk and Nassau Counties). Should be alternated with protectant fungicides.

5. Cymoxanil, propamocarb, and dimethomorph have been available through Section 18 labels. Cymoxanil now has a Section 3 label in some states.

Use in IPM Programs: An IPM approach to managing late blight includes the use of disease forecasting computer software; maintenance of a network of weather stations; a system of rapid notification about area outbreaks; and a program of protectant fungicide applications dependent on crop stage, weather factors, and inoculum availability. Use of protectant and systemic fungicides is consistent with Cornell IPM recommendations.

Efficacy Issues and Use in Resistance Management Programs: The recent introduction of metalaxyl-resistant strains of late blight has had a dramatic impact on foliar disease management in potatoes. While late blight was once an occasional disease easily controled by metalaxyl applications, it now drives fungicide use in potatoes. Although several systemic fungicides (cymoxanil, propamocarb, and dimethomorph) provide some curative action on infected plants, their efficacy is limited. Until a fungicide with the historical efficacy of metalaxyl is available for use, the best strategy for late blight control includes consistent coverage with protectant fungicides. This can be a reasonably effective strategy, but it is expensive for producers and results in significantly higher use of fungicides in potatoes.

Alternatives: Azoxystrobin (Quadris; Zeneca) will provide another alternative for late blight control.

3. Early Blight *(Alternaria solani)*

Frequency of Occurrence: Annually.

Damage Caused: Early blight causes spots on potato leaves and stems, and occasionally on tubers, especially at the stem end. When spots are extensive, leaves yellow and senesce prematurely. If infections are severe and many leaves killed, yields will be reduced.

% Acres Affected: 100%

Pest Life Cycles: The early blight fungus survives the winter in plant refuse in soil. Any factor that affects optimal potato plant growth can predispose the plant to early blight. Development of early blight is accelerated by high temperatures and high relative humidity.

Timing of Control: Early July through harvest.

Yield Losses: Can be up to 50% in severely affected fields.

Regional Differences: None.

Cultural Control Practices: Several varieties have some resistance to the disease. Rotation away from solanaceous crops for a minimum of two years is recommended. Use of disease-free seed is important. Allowing tubers to mature in the ground for at least two weeks after the vines die reduces tuber infection. Wounding tubers during harvesting should also be avoided.

Biological Control Practices: None.

Post-Harvest Control Practices: Plow under all plant debris and volunteer potatoes immediately after harvest.

Chemical Controls: See “Late Blight” section, above, for pesticide use information.

Use in IPM Programs: Use of fungicides is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: None reported.

Alternatives: Azoxystrobin (Quadris; Zeneca) can be effectively utilized in an alternate spray program with protectant fungicides.

4. Botrytis Vine Rot *(Botrytis cinerea)*

Frequency of Occurrence: Sporadic.

Damage Caused: The fungus may infect and weaken stems under the right weather conditions.

% Acres Affected: 100% at risk; typically 5% affected per year.

Pest Life Cycles: *Botrytis cinerea* is a commonly occurring soil fungus. The fungus typically attacks dead tissue and can be seen as a fuzzy, grey growth on dead blossoms or senescent leaves. Under wet conditions and when vine growth is lush, the fungus may move into the stem tissue. The stem rot is initially wet and slimy. The fungus sporulates on infected tissue and produces a dense, gray to off-white growth.

Timing of Control: July and August.

Yield Losses: Usually minimal.

Regional Differences: None.

Cultural Control Practices: Nitrogen rates that result in excess vine growth aggravate this disease. Planting in poorly drained soils should be avoided. No resistant varieties are available.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See “Late Blight” section, above, for pesticide use information.

Use in IPM Programs: Use of fungicides is consistent with Cornell IPM recommendations.

Use in Resistance Management Programs: None reported.

Alternatives: None available at this time.

5. White Mold *(Sclerotinia sclerotiorum)*

Frequency of Occurrence: Sporadic.
Damage Caused: The fungus attacks stems, generally at the soil line, weakening the plant.
% Acres Affected: <1%
Pest Life Cycles: The causal fungus, *Sclerotinia sclerotiorum,* is a common soilborne pathogen in NY vegetable soils. It generally infects stems at the soil line, but infection can occur on any part of the plant. Symptoms include dense, cottony white growth and the productionof hard, black, irregularly shaped sclerotia on infected tissue. The disease is not common on potatoes in NY.
Timing of Control: July and August.
Yield Losses: Usually minimal.
Regional Differences: None.
Cultural Control Practices: Excessive irrigation and high nitrogen rates should be avoided. Rotation with grains (but not beans) reduces soil populations. No resistant varieties are available.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Chemical Controls: See "Late Blight" section, above, for information on pesticide use.
Use in IPM Programs: As-needed use of fungicides is consistent with Cornell IPM recommendations.
Use in Resistance Management Programs: None reported.
Alternatives: None available at this time.

6. Pink Rot *(Phythophthora erythroseptica)*

Frequency of Occurrence: Annually.
Damage Caused: The fungus infects tubers. External symptoms appear around the stem end or eyes and lenticels. The infected area turns purple to dark brown with a black band. Tubers become rubbery or spongy and exude a liquid when squeezed. When cut, the infected tissue turns pink in a matter of minutes, then darkens to brown and finally to black. The pathogen will spread in storage if potatoes are not kept dry.
% Acres Affected: 100% at risk; up to 10% affected per year.
Pest Life Cycles: The fungus, *Phytophthora erythroseptica*, is soilborne and endemic in many soils. Zoospores, sporangis, or oospores may serve as inoculum, but oospores are probably the significant propagule in pathogen disseminations and survival in soil. Plants of all ages are susceptible but the disease is most frequently observide in mature plants approaching harvest.
Timing of Control: All season.
Yield Losses: Can be up to 50% in severely affected fields or storage lots.
Regional Differences: None.
Cultural Control Practices: Avoid planting in poorly drained areas. Plant disease-free seed.
Biological Control Practices: None.
Post-Harvest Control Practices: None.

Soil Fungicides and Fumigants for Potato Disease Control:

Pesticide	Target Disease[1]	% Trt.	Type of Appl.	Typical Rates lbs ai/acre	Timing	# of Appl.	PHI days	REI hours
mefenoxam[2] *(Ridomil Gold)*	PR, L	10-15 U & LI	foliar, ground	1.4	after flowering	1	14	48
metam sodium *(Vapam)*	V, F, C	<1 U 3 LI	soil fumigation	127	preceding fall	1	200	?

1. Key: PR=Pink rot; V=Verticillium; F=Fusarium; L=Leak; C=Canker
2. Usually combined with mancozeb or chlorothalonil.

Use in IPM Programs: As-needed use of fungicides is consistent with Cornell IPM recommendations.
Use in Resistance Management Programs: Resistance to mefenoxam is present in some strains of the pink rot fungus.
Alternatives: None available at this time.

7. Verticillium wilt *(Verticillium albo-atrum* and *V. dahliae)*

Frequency of Occurrence: Sporadic.

Damage Caused: These fungi cause vascular wilts in potatoes. Plants infected early during warm weather become stunted, wilt, or die. Later in the season wilting, yellowing or premature death occurs. The disease is often more severe when the lesion nematode (*Pratylenchus penetrans*) is prevalent.

% Acres Affected: 100% at risk; up to 25% affected.

Pest Life Cycles: *Verticillum albo-atrum* and *V. dahliae* are common soil-dwelling fungi with wide host ranges. They overwinter in soil and in and on old potato tubers as mycleium or small, dark black microsclerotia. The pathogens can survive for several years without a host crop and will infect and reproduce on certain weeds.

Timing of Control: Before planting.

Yield Losses: Can be up to 30% in severely affected fields. Typical losses run 1-10%.

Regional Differences: None.

Cultural Control Practices: Late maturing varieties are more resistant thatn early-maturing varieties. Rotation with grains reduces soil populations. Rotation away from potatoes as frequently as possible is recommended.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See "Pink Rot" section, above, for pesticide use information.

8. Fusarium wilt *(Fusarium* spp.*)*

Frequency of Occurrence: Annually.

Damage Caused: Fusarium species can cause wilt, seedpiece decay, and tuber rots (see other sections). Fusarium wilt occurs when the fungus attacks the vascular system of the plant. Severely infected plants can wilt, turn yellow, and collapse. Tuber lesions can also occur.

% Acres Affected: 100% at risk; up to 25% affected.

Pest Life Cycles: Fusarium wilt of potato is caused by *F. oxysporum* and *F. solani*. Both fungi are common soil inhabitants that increase in numbers with continued potato culture. Both survive in soil as dormant spores or in crop refuse. Infection is favored by hot weather and high soil moisture. Small feeder roots come in contact with dormant spores, which germinate and invade the roots. The fungus moves up the plant through the vascular system.

Timing of Control: Before planting.

Yield Losses: Can be up to 50% in severely infected fields. Typical losses are 1-10%.

Regional Differences: None.

Cultural Control Practices: No resistant varieties are available. Crop rotation is not useful because the fungi survive in the soil for long periods without host plants.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See "Pink Rot" section, above, for pesticide use information.

9. Leak *(Pythium* spp.*)*

Frequency of Occurrence: Annually.

Damage Caused: Infected tubers show lesions, typically around wounds or near the stem. A freshly cut tuber turns reddish tan, then brown and finally black. Infected tubers decay during storage.

% Acres Affected: 100% of acres are at risk; typically 5-20% are affected.

Pest Life Cycles: A number of fungi in the *Pythium* genus infect potato tubers. They are common inhabitants of soils, and have a very wide host range.

Timing of Control: At planting, and at flowering.

Yield Losses: Can be up to 75% in severely affected fields. Typical losses range from 1-15%.

Regional Differences: None.

Cultural Control Practices: No resistant varieties are available. Seed should be disease-free. Avoid harvesting immature tubers during hot or wet weather. Storage temperatures should be kept low if the disease is detected.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See "Pink Rot" section, above, for pesticide use information.

10. Canker *(Rhizoctonia solani)*

Frequency of Occurrence: Sporadic.

Damage Caused: This fungus causes a variety of symptoms on tubers including cracking, malformation, and russetting. It can cause a black scurf on tuber surfaces, rendering them unmarketable. The fungus can also cause a stem canker, which can greatly weaken plants and decrease yields. Finally, the fungus attacks undergound sprouts before they can emerge.

% Acres Affected: 100% at risk of infection; typically 5% affected per year.

Pest Life Cycles: *Rhizoctonia solani* is a common inhabitant of soils in New York. The scurf found on infected tubers at harvest and in storage, seen as numerous small, black, hard raised bumps, are actually the survival structures, called sclerotia. Disease development is favored by cool, wet soils. Inoculum usually is introduced into fields on potato seed tubers, or by contaminated soil. Sclerotia in soil or on seed pieces germinate, and the resulting mycelium colonizes plant surfaces. The fungus penetrates young, susceptible tissue. Sclerotia form on tubers and in soil. At the end of the growing season, the fungus produces its sexual state, *Thanetephorus cucumeris*, on stems just above the soil line.

Timing of Control: All season.

Yield Losses: Incidence can be as high as 50% in severely affected fields, resulting in reduced marketability of 10% or more.

Regional Differences: None.

Cultural Control Practices: No resistant varieties are available. A rotation to corn or grain crops of at least three years is recommended. Heavy, poorly drained soils should be avoided. Seed should be disease-free. The time between vine-kill and harvest should be minimized.

Biological Control Practices: None.

Post-Harvest Control Practices: None.

Chemical Controls: See “Pink Rot” section, above, for pesticide use information.

11. Black Dot and Root Rot *(Colletotrichum coccodes)*

Frequency of Occurrence: Sporadic.

Damage Caused: This disease causes a root decay and reduction of root growth. Tubers can become infected, becoming discolored or spotted.

% Acres Affected: 100% at risk of infection; typically 1-2% affected.

Pest Life Cycles: Overwintering of the fungal pathogen is by sclerotia on the surface of tubers or in plant debris in the field. The pathogen does not appear to be an active soil inhabitant, but it may survive in soil for long periods. This disease is most frequently associated with light sandy soils, low nitrogen, high temperatures, and poor soil drainage.

Timing of Control: At planting.

Yield Losses: Can be up to 75% in severely infected fields.

Regional Differences: None.

Cultural Control Practices: Cultural control practices are the sole available means of managing this disease. The include: avoiding plant stress; minimum two year rotation to a grain crop; avoiding rotation with tomatoes; managing solanaceous weeds; and planting disease-free seed.

Biological Control Practices: None.

Post-Harvest Control Practices: Deep plowing will bury infected debris and promote decompostion.

Chemical Controls: No pesticides are registered to manage this disease.

12. Golden nematode *(Globodera rostochiensis)*

Frequency of Occurrence: Restricted to specific regions of the state. A state quarantine exists for this nematode.

Damage Caused: Infected plants exhibit chlorosis, stunting, and sometimes early death. The roots of plants may be short, swollen and brownish. Yields are diminished.

% Acres Affected: 100% at risk of infection, typically 1% affected.

Pest Life Cycles: The golden nematode is a pathogen on potatoes, tomatoes, eggplant, and a number of solanaceous weeds. The golden nematode may survive as cysts in the soil for as many as 30 years without a suitable host crop. Once the nematode has become established in a field, eradication is extremely difficult. Nematode eggs within cysts are stimualted by root exudates of growing potatoes to hatch in the spring. Usually only half the eggs or fewer hatch each spring. Juveniles enter the plant root t feed. During a period of three molts, juveniles become females remaining attached within the root, or males which leave the root. After fertilization the female body swells with developing eggs and protrudes outside the root. The female body becomes the outer covering of the cyst, containing the eggs.

Timing of Control: Before planting.

Yield Losses: Due to quarantine, losses can be 100% in affected fields.

Regional Differences: In the US, this pest is only found in New York, in certain counties in the central and western regions of the

state.
Cultural Control Practices: Planting resistant varieties is the major control measure. Fields should be rotated away from solanaceous crops. Solanaceous weeds should be eliminated.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Other Issues: New York is the only state to have golden nematode. A joint USDA and Cornell University program over the past 25 years has developed many golden nematode resistant varieties. Regulatory authorities mandate the use of resistant potato varieties as a method of control.
Chemical Controls: No pesticides are registered to manage this nematode.

13. Potato Scab *(Streptomyces spp.)*

Frequency of Occurrence: Some scab is seen in potato growing areas annually, but usually at low levels.
Damage Caused: Scab causes cosmetic damage to tubers, running from superficial russetting to deep pitting.
% Acres Affected: 100% at risk of infection; typically 2% affected per year.
Pest Life Cycles: The bacterium can overwinter in infected seedpieces and contaminated soil. It thrives in soil when the pH range is 5.5 to 7.5, although there is an “acid-scab” which can occur in soils with a pH below 5.2. The organism can be spread by contaminated manure if livestock have been fed infected tubers. The bacterium infects actively growing tubers through the lenticels or through wounds caused by mechanical damage or insect feeding.
Timing of Control: Before planting.
Yield Losses: Losses due to cosmetic damage run as high as 75%, but this is very unusual. Typical losses are 1-5%.
Regional Differences: None.
Cultural Control Practices: Cultural control practices are the major method for controlling this disease. Recommended practices include: planting resistant varieties; rotation away from potatoes and other host crops including red clover; avoiding light-textured soils; maintaining pH below 5.2; and maintaining adequate moisture during the six weeks following tuber set.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Chemical Controls: No pesticides are available to manage this disease.

14. Bacterial Ring Rot *(Cornybacterium sepedonicum* subsp. *sepedonicum)*

Frequency of Occurrence: Rare.
Damage Caused: This bacterial disease can cause stem to collapse, and infected tubers exhibit discoloration of the vascular tissue and the stem end. When infected tubers are squeezed, a milky substance oozes from it. Secondary organisms attack infected tubers in storage and may cause skin cracks and further discoloration. Potatoes grown for seed must have 0% bacterial ring rot.
% Acres Affected: 100% at risk of infection; typically <1% affected per year.
Pest Life Cycles: The disease-causing bacterium overwinters in infected tubers and on contaminated equipment. At planting, seed potatoes may already be infected or they may become infected during the process of planting. Cutting knives can spread the inoculum. Some insects can transmit the bacterium, and it can be spread in irrigation water or from plant to plant be root contact. Infection occurs only through wounds. Bacteria may invade the xylem vessels and plug vascular tissue. Presence of bacteria in the roots causes the deterioration of feeder roots, contributing to the wilting of the plant.
Timing of Control: Before planting.
Yield Losses: Can be up to 100% in severely affected fields.
Regional Differences: None.
Cultural Control Practices: No resistant varieties are available. The key to managing this disease is the use of certified disease-free seed. Equipment and containers should be disinfected between seed lots. All tuber handling equipment and storage areas must be disinfected if the disease occurs.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Chemical Controls: No pesticides are registered to manage this disease.

15. Powdery Scab *(Spongospora subterranea)*

Frequency of Occurrence: Sporadic.
Damage Caused: Damage is similar to that caused by scab, but the texture of the lesions are powdery. In storage, powdery scab may lead to dry rot, and infections can spread in storage.
% Acres Affected: <5%

Pest Life Cycles: The fungus survives in soil as resting spores. After germinating, spores infect roots, stolons, and tubers. Invasion by spores stimulates the host cells to become larger and more numerous, and galls are produced. Within these galls, ball of resting spores are produced.
Timing of Control: Before planting.
Yield Losses: Usually small, 1-5%.
Regional Differences: None.
Cultural Control Practices: Avoid planting in low spots with poor drainage. Plant disease-free seed.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Chemical Controls: No pesticides are registered to manage this disease.

16. Silver Scurf *(Helminthosporium solani)*

Frequency of Occurrence: Annually.
Damage Caused: This disease causes cosmetic damage to tubers. Buyers are increasingly unwilling to purchase tablestock potatoes showing silver scurf lesions. Silver scurf infects only the skin on the potato. Symptoms appear at the stolon end as small, pale, brown spots. Severe browing of the surface layers of tubers may occur, followed by sloughing-off of the outer layers of the periderm.
% Acres Affected: 100%
Pest Life Cycles: Silver scurf is caused by the soilborne fungus, *Helminthosporium solani*. It is primarily a disease of mature tubers that becomes evident just before harvest.
Timing of Control: Before planting.
Yield Losses: Can be as high as 75% in severely affected fields.
Regional Differences: None.
Cultural Control Practices: No resistant varieties are available. Disease-free seed should be planted. Tubers should be harvested early.
Biological Control Practices: None.
Post-Harvest Control Practices: Cool temperatures and low relative humidity slow the spread of silver scurf in storage.
Other Issues: (Note Maxim seed treatment in table). Because of the increasing importance of this disease in tablestock potatoes, research on its biology and control is ongoing (Loria).
Chemical Controls: No pesticides are registered to manage this disease. The industry has a critical need for an effective control for silver scurf in tablestock and seed potatoes.

17. Bacterial Soft Rot *(Erwinia spp.)*

Frequency of Occurrence: Some bacterial soft rot is found in most growing areas each year, although usually at low levels.
Damage Caused: *Erwinia* spp. can cause a blackening and decay of the stem (known as "black leg"), and soft rot of infected tubers. Yield and quality can be diminished.
% Acres Affected: 100% at risk of infection; typically 5-15% affected per year.
Pest Life Cycles: Bacteria may overwinter in the soil or in plant debris, but more commonly overwinter in infected seedpieces. The bacteria can spread to healthy seedpieces readily during cutting and planting. Bacteria from an infected plant may infect tubers through the soil water. Tubers are infectes through wounds or lenticels, and these bacteria survive the entire storage period. Tubers harvested when soil temperatures are high or those grown under conditions of high nitrogen are highly susceptible to soft rot. Environmental factors that create anaerobic conditions, such as poor aeration, flooding, or a water film on tubers, favor disease development. Soft rot bacteria can also act as secondary pathogens in tubers infected with other diseases.
Timing of Control: Before planting.
Yield Losses: Can be as high as 100% in severely affected fields. Typical losses run from 1-10%.
Regional Differences: None.
Cultural Control Practices: Avoid poorly drained areas, and injuries to the tuber during harvest. Plant disease-free seed.
Biological Control Practices: None.
Post-Harvest Control Practices: The use of chlorine was treatments can prevent the spread of decaying bacteria by killing the organism on contact. Provide good conditions for wound healing for two to three weeks after harvest. Following this, temperatures should be kept as low as possible.

Post-Harvest Fungicides and Disinfectants for Potato Disease Control:

Pesticide	Disease	% Trt.	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI days	REI hours
chlorine *(AgClor)*	Erwinia	1-5	in wash water	25-100 ppm	postharvest	1	--	--
thiabendazole *(Mertect)*	Fusarium	1-5	mist application	0.42 fl. oz	postharvest	1	--	12

Use in IPM Programs: Use of chlorine in wash water is consistent with Cornell IPM recommendations.
Use in Resistance Management Programs: None.
Alternatives: None at this time.

18. Fusarium Dry Rot *(Fusarium sambucinum* and *F. solani)*

Frequency of Occurrence: Annually.
Damage Caused: This disease causes a dry rot of potatoes in storage. Symptoms include cunken and shriveled areas on the surface of tubers. The rot may extend to the center of the tuber and contain a fungal growth. Affected tissue often becomes colonized by soft rot bacteria.
% Acres Affected: 100% of acres at risk of infection; typically 10-25% of acreas are affected.
Pest Life Cycles: The causal fungi (*Fusarium sambucinum* and *F. solani*) cause dry rot in stored tubers as well as in seed pieces (see "Seedpiece Decay and Seedborne Pathogens Section"). *Fusarium* spp. can survive for several years in field soil, but the primary inoculum is generally borne on seed tuber surfaces. Infected seed tubers and pieces decay and infest the soil that adheres to the surfaces of harvested tubers. Tubers become more susceptible to infection during storage, especially during the spring.
Timing of Control: Planting, harvest, and postharvest.
Yield Losses: Can be up to 75% in severely affected storages.
Regional Differences: None.
Cultural Control Practices: Purchase seed with as little dry rot as possible. Seed becomes more susceptible as the storage season progresses. Warm seed to at least 50oF before handling and cutting; and minimize bruising.
Biological Control Practices: None.
Post-Harvest Control Practices: Harvest tubers after skins are set and when pulp temperature is greater than 50oF. Avoid injuries through which the fungus can infect tubers. Cure tubers carefully after harvest, and follow with storage under as low a temperature as possible. Do not move potatoes in storage.
Other Issues: Because of the problems of resistance to both thiophanate-methyl and thiabendazole, research has been conducted on new seed piece fungicides (Loria), including Maxim.
Chemical Controls: See "Bacterial Soft Rot" section, above, for pesticide use information.
Use in Resistance Management Programs: Problems with resistant strains of Fusarium have caused the use of thiabendazole to decrease significantly. The industry has a need for other effective control measures for Fusarium dry rot.
Alternatives: None at this time.

19. Viruses *(several)*

Frequency of Occurrence: Sporadic.
Damage Caused: Virus infections can cause distorted growth, stunting, distortions in leaf coloration, and small misshapen tubers.
% Acres Affected: 100% at risk of infection; typically <1% are affected.
Pest Life Cycles: Several viruses and a viroid are spread by potato tubers. These include potato leaf roll virus (PLRV), potato virus Y (PVY), potato virus A (PVA), potato viruses S and M (PVS and PVM), alfalfa mosaic virus (AMV), potato spindle tuber viroid (PSTV). These viruses are spread by tuber seedpieces. Some are also spread by aphids and by mechanical means.
Timing of Control: Before planting, and during the season.
Yield Losses: Usually small.
Regional Differences: None.
Cultural Control Practices: The major method for controlling viruses in potatoes is through the production of disease-free seed potatoes. This is controlled through the New York Foundation and Certified Seed programs. Potato stocks are tested for viruses.
Biological Control Practices: None.
Post-Harvest Control Practices: None.
Chemical Controls: No pesticides are registered to control viruses. However, control of aphid vectors using insecticides can be effective, especially in seed potato production.

VI. Pest Information: Weeds, Vine-killing, and Sprout Inhibitors

1. Annual and Perennial Broadleaves and Grasses

Frequency of Occurrence: Annually.

Damage Caused: Reduced yields from weed competition; interference with harvesting; weeds act as alternate hosts of diseases and nematodes.

% Acres Affected: 100%

Pest Life Cycles: Annual and perennial weeds such as yellow nutsedge, redroot pigweed, quackgrass, annual grasses, common lambsquarters, common ragweed, velvetleaf, mustards, nightshades, and bindweed are a problem throughout the growing season.

Timing of Control: Preplant, preemergence, and postemergence.

Yield Losses: Yield losses can be as high as 100% if weeds are not controlled by herbicides or cultivation. Typical losses to weeds run 1-5%.

Regional Differences: While weed species spectra may vary regionally, weeds are a problem in all potato growing areas of the state.

Cultural Control Practices: Cultivation is an important cultural practice used to control weeds. According to a survey of potato growers conducted in 1996, 99% cultivate potatoes. Most cultivate 2-3 times, and some cultivate as many and four times per season. About 20% use handweeding on limited acreage to control especially difficult weeds. Banding herbicides can be a useful practice in potatoes, but this has not been widely adopted.

Biological Control Practices: None.

Post-Harvest Control Practices: Cultivation. Post-harvest application of herbicides to control perennial weeds.

Other Issues: Research on weed control in potatoes is ongoing (Bellinder). The focus of this research is screening new herbicides for efficacy and crop tolerance, and testing methods to lower herbicide use rates. The use of living mulches, suppressed by low rates of herbicides, has shown some promising results.

Potato Herbicides:

Pesticide	% Trt.	Typical Rates lbs ai/acre	Timing and Type of Application	# of Appl.	PHI days	REI hours
EPTC *(Eptam)*	1-5	5.9	preplant; soil incorporated	1	90	12
trifluralin *(Treflan)*	1-5	1.0	preplant; soil incorporated	1	90	12
metolachlor[1] *(Dual)*	50	1.5-2.0	preplant soil incorporated; soil surface, preemerge or postemerge	1	75	12
linuron[2] *(Lorox)*	30	1.0-1.5	soil surface, preemerge	1	75	24
metribuzin *(Sencore/Lexone)*	85-90	0.375-0.75	soil surface, preemerge or postemerge	1	60	12
pendimethalin *(Prowl)*	1-5	1.0	soil surface, preemerge	1	75	12
sethoxydim *(Poast)*	5-10	0.2-0.45	soil surface, postemerge	1	60	12
rimsulfuron[3] *(Matrix)*	1-5	0.016	soil surface, preemerge or postemerge	1	60	4
paraquat *(Gramoxone)*	1-2	0.47	soil surface, preemerge	1	60	12
2,4-D[4] *(Formula 40)*	10	varies with formulation	soil surface, preplant or postharvest	1	60	48
glyphosate *(Roundup)*	45	1.0	soil surface, preplant or postharvest	1	100	4

1. Approximately 95% of potato acres on Long Island are treated, and 30-35% in upstate NY.
2. Used on approximately 10% of potato acres on Long Island, and on 35% in upstate NY.
3. First available in 1998; use is expected to increase.

4. A 24(c) label was recently granted by the NYS Dept. Environmental Conservation allowing the use of low rates of 2,4-D, postemergence, on red potatoes. This use improves tuber skin color at harvest.

Use in IPM Programs: Use of each of these materials is consistent with Cornell IPM recommendations. Post-emergence materials (metribuzin, metolachlor, sethoxydim, and rimsulfuron) support the use of scouting and as-needed applications.

Use in Resistance Management Programs: None reported.

Efficacy Issues: The listed herbicides have different but overlapping spectra of species control (for complete information, see Reference # RECOMMENDS). Producers must also take into account differences in soil type (i.e. muck vs. mineral soils) in making herbicide selections. Glyphosate and 2,4-D are used primarily for control of field bindweed and quackgrass in the fall preceding a potato crop. Despite the number of herbicides available to growers, control of problem weeds such as yellow nutsedge, redroot pigweed, and quackgrass remain difficult. The loss of metribuzin would have significant impacts on production and profitability if new effective alternatives were not registered. The industry has a critical need for more herbicide options for effective weed control on a range of soil types.

Alternatives: *Anything new out there??*

2. Vine-killing and Sprout Inhibitors

Frequency of Occurrence: Annually.

Vine-killers and Sprout Inhibitors Used in Potatoes:

Chemical	Use	% Trt.[1]	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI days	REI hours
paraquat[1] *(Gramoxone)*	vine-kill	60-80	foliar	0.3 lbs ai/acre	14 days before harvest	1	7	12
diquat[2] *(Diquat)*	vine-kill	50-60	foliar	0.5 lbs ai/acre	14 days before harvest	1	7	24
endothal *(Desicate II)*	vine-kill	<1	foliar	1.0 lbs ai/acre	14 days before harvest	1	10	48
CIPC *(Sprout-Nip)*	sprout inhibitor	35	direct to tubers	1.0 lb ai/4200 cwt	postharvest	1	--	--
maleic hyrdazide[3] *(MH)*	sprout inhibitor	20	foliar	varies with formulation	2 weeks before vine kill	1	--	12

1. Label no longer supports use as a vine-killing agent.
2. Use is expected to increase due to changes in paraquat label.
3. Use may increase as growers seek ways to minimize sprouting of potatoes left in the field, since these can be a significant source of late blight inoculum, threatening crops the following year.

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8. Members of the Upstate New York Potato Advisory Committee, comprised of producers, consultants, researchers and Extension Educators, and members of the Empire State Potato Club (producers), provided detailed information and perspectives on industry needs for this Crop Profile. Much of the information was drawn from surveys of key potato producers in upstate NY and in Long Island. Drafts of this Crop Profile were reviewed by producers, researchers, and Extension agents to ensure accuracy and completeness.