2016

Organic Production and IPM Guide for Potatoes

NYS IPM Publication No. 138

Cornell University Cooperative Extension

Integrated Pest Management

New York State Department of Agriculture & Markets

2016 Production Guide for
Organic Potato

Coordinating Editor

Abby Seaman* (Cornell University, New York State Agricultural Experiment Station, New York State IPM Program)

Contributors and Resources

George Abawi (Cornell University, Section of Plant Pathology and Plant Microbe Biology, retired)

Michael Glos (Kingbird Farm, Richford, NY)

Beth Gugino (The Pennsylvania State University, Department of Plant Pathology)

Don Halseth (Cornell University, Section of Horticulture, retired)

Michael Helms* (Cornell University, Pesticide Management Education Program)

Andy Leed (Starflower Farm, Candor NY)

Margaret T. McGrath* (Cornell University, Section of Plant Pathology and Plant Microbe Biology)

Charles L. Mohler (Cornell University, Section of Soil and Crop Sciences, retired)

Brian Nault* (Cornell University, Department of Entomology)

Anusuya Rangarajan (Cornell University Horticulture-SIPS, Vegetable Crop Production)

Ward M. Tingey (Cornell University, Department of Entomology, Emeritus)

Thomas A. Zitter (Cornell University, Section of Plant Pathology and Plant Microbe Biology, retired)

**Pesticide Information and Regulatory Compliance*

Staff Writers

Mary Kirkwyland and Elizabeth Thomas (Cornell University, NYSAES, New York State IPM Program)

Editing for the 2016 update

Mary Kirkwyland (Cornell University, NYSAES, New York State IPM Program)

Special Appreciation

Format based on the Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production (https://ipmguidelines.org/ Reference 1). Content Editors Stephen Reiners and Abby Seaman, with numerous discipline editors

Funded through a grant from the New York State Department of Agriculture and Markets

The information in this guide reflects the current authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this guide does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

Every effort has been made to provide correct, complete, and up-to-date pest management information for New York State at the time this publication was released for printing (June 2016). Changes in pesticide registrations and regulations, occurring after publication are available in county Cornell Cooperative Extension offices or from the Pesticide Management Education Program web site (*http://pmep.cce.cornell.edu*). Trade names used herein are for convenience only. No endorsement of products in intended, nor is criticism of unnamed products implied.

This guide is not a substitute for pesticide labeling. Always read the product label before applying any pesticide.

Updates and additions to this guide are available at http://nysipm.cornell.edu/resources/publications/organic-guides. Please submit comments or suggested changes for these guides to organicguides@gmail.com.

How to cite this publication: Seaman, Abby, editor (2016). *Production Guide for Organic Potato*. Publisher: New York State Integrated Pest Management Program, Cornell University (New York State Agricultural Experiment Station, Geneva, NY). 98 pages.

Contents

INTRODUCTION

This guide for organic production of potatoes provides an outline of cultural and pest management practices and includes topics that have an impact on improving plant health and reducing pest problems. It is divided into sections, but the interrelated quality of organic cropping systems makes each section relevant to the others.

This guide attempts to compile the most current information available, but acknowledges that effective means of control are not available for some pests. More research on growing crops organically is needed, especially in the area of pest management. Future revisions will incorporate new information providing organic growers with a complete set of useful practices to help them achieve success.

This guide uses the term Integrated Pest Management (IPM), which like organic production, emphasizes cultural, biological, and mechanical practices to minimize pest outbreaks. With limited pest control products available for use in many organic production systems, an integrated approach to pest management is essential. IPM techniques such as identifying and assessing pest populations, keeping accurate pest history records, selecting the proper site, and preventing pest outbreaks through use of crop rotation, resistant varieties and biological controls are important to producing a high quality crop.

1. GENERAL ORGANIC MANAGEMENT PRACTICES

1.1 Organic Certification

To use a certified organic label, farming operations grossing more than $5,000 per year in organic products must be certified by a U.S. Department of Agriculture National Organic Program (NOP) accredited certifying agency. The choice of certifier may be dictated by the processor or by the target market. A list of accredited certifiers (Reference 10) operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Development/Assistance web page (Reference 11). See more certification details under Section 4.1: *Field Selection: Certification Requirements* and Section 11: *Using Organic Pesticides.*

1.2 Organic System Plan

An organic system plan (OSP) is central to the certification process. The OSP describes production, handling, and record-keeping systems, and demonstrates to certifiers an understanding of organic practices for a specific crop. The process of developing the plan can be very valuable in terms of anticipating potential issues and challenges, and fosters thinking of the farm as a whole system. Soil, nutrient, pest, and weed management are all interrelated on organic farms and must be managed in concert for success. Certifying organizations may be able to provide a template for the farm plan. The following description of the organic system plan is from the USDA National Organic Program Handbook:

> "A plan of management of an organic production or handling operation that has been agreed to by the producer or handler and the certifying agent and that includes written plans concerning all aspects of agricultural production or handling described in the Organic Food Production Act of 1990 and the regulations in Subpart C, Organic Production and Handling Requirements."

The National Sustainable Agriculture Information Service, (formerly ATTRA), has produced a Guide for Organic Crop Producers that includes a chapter on writing the organic system plan. The Rodale Institute has also developed resources for transitioning to organic and developing an organic system plan.

1.3 Critical management strategies

While this guide contains many management strategies for organic potato production, Table 1.3.1, based on recommendations from a successful organic potato grower, summarizes those that are critically important.

Table 1.3.1 Critical management considerations

Challenge	Considerations
Planting date	Plant too early and potatoes rot or get frosted; plant too late and the risk of late blight and insufficient time to mature can severely affect yield. Take advantage of the good 3 week planting window that usually begins and ends in May. See Section 7: *Planting methods*.
Weed management	This is very important. Poor weed control can severely decrease yields, increase disease by preventing airflow, and interfere with harvest by clogging harvest equipment. Weeds impede hand harvesting as well. Multiple well-timed cultivations with hilling can be very effective even when previous cultural control was poor. Be ready to cultivate when the weather permits and crop and weed timing dictate. See Section 5: *Weed management.*
Insect control	The most troublesome insects are the Colorado potato beetle (CPB) and the potato leafhopper (PLH). For CPB, very effective results are achieved on a small scale by picking adults and on a larger scale with 1-2 sprays of Entrust at the early larval stages (See Section 15.1). Damage inflicted by PLH is very variety-dependent. Select varieties that can withstand PLH damage because organically approved sprays may not work or be cost effective. See Section 6: *Varieties*.

Challenge	Considerations
Disease control	The disease of greatest concern is late blight. Always follow the recommended late blight cultural controls (Section 12.4: *Late blight*). In years where conditions are very favorable for late blight, organic growers will likely be affected and could suffer yield decreases of at least 50%. Factor this into the cost of growing the crop. Many growers experience late blight in 1 out of 5 years. Sprays labeled for late blight are available, but their effectiveness is not 100% and is very much dependent on the adequacy of spray equipment, frequency of spray, and timing of initial spray relative to development of the disease.

2. Soil Health

Healthy soil is the basis of organic farming. Regular additions of organic matter in the form of cover crops, compost, or manure create a soil that is biologically active, with good structure and capacity to hold nutrients and water (note that any raw manure applications must occur at least 120 days before harvest). Decomposing plant materials will activate a diverse pool of microbes, including those that break down organic matter into plant-available nutrients as well as others that compete with plant pathogens in the soil and on the root surface.

Rotating between crop families can help prevent the buildup of diseases and nematodes that overwinter in the soil. Rotation with a grain crop, or preferably a crop or crops that will be in place for one or more seasons, deprives many, but not all, disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. The same practices are effective for preventing the buildup of root damaging nematodes in the soil, but keep in mind that certain grain crops are also hosts for some nematode species. Rotating between crops with late and early season planting dates can reduce the buildup of weed populations. Organic growers must attend to the connection between soil, nutrients, pests, and weeds to succeed. An excellent resource for additional information on soils and soil health is the online e-book, Building Soils for Better Crops (Reference 15). For more information, refer to the Cornell Soil Health website (Reference 16).

3. Cover Crops

Unlike cash crops, which are grown for immediate economic benefit, cover crops are grown for their valuable effect on soil properties and on subsequent cash crops. Cover crops help maintain soil organic matter, improve soil tilth, prevent erosion and assist in nutrient management. They can also contribute to weed management, increase water infiltration, maintain or increase populations of beneficial fungi, and may help control insects, diseases and nematodes. Beneficial fungi create a competitive environment in the soil, as they fight with plant pathogenic fungi for limited resources. To be effective, cover crops should be treated as any other valuable crop on the farm, carefully considering their cultural requirements, life span, mowing recommendations, incorporation methods, and susceptibility, tolerance, or antagonism to root pathogens and other pests. See Tables 3.1 and 3.2 for more information on specific cover crops and Section 8: *Crop and Soil Nutrient Management* for more information about how cover crops fit into nutrient management.

A certified organic farmer is required to plant certified organic cover crop seed. If, after contacting at least three suppliers, organic seed is not available, then the certifier may allow untreated conventional seed to be used. Suppliers should provide a purity test for cover crop seed. Always inspect the seed for contamination with weed seeds and return if it is not clean. Cover crop seed is a common route for introduction of new weed species onto farms.

3.1 Goals and Timing for Cover Crops

Adding cover crops regularly to the crop rotation plan can result in increased yields of the subsequent cash crop. Goals should be established for choosing a cover crop; for example, the cover crop can add nitrogen, smother weeds, or break a pest cycle. See the Cornell online decision tool to match goals, season, and cover crop (reference 17). The cover crop might best achieve some of these goals if it is in place for the entire growing season. If this is impractical, a compromise might be to grow the cover crop between summer cash crops. Allow two or more weeks between cover crop incorporation and cash crop seeding to permit decomposition of the cover crop, which will improve the seedbed and help avoid any unwanted allelopathic effects on the next cash crop. Another option is to overlap the cover crop and the cash crop life cycles by overseeding, interseeding or intercropping the cover crop between cash crop rows at final cultivation. An excellent resource for determining the best cover crop for your situation is Northeast Cover Crop Handbook by Marianne Sarrantonio (Reference 19).

Leaving cover crop residue on the soil surface might make it easier to fit into a crop rotation and will help to conserve soil moisture but some of the nitrogen contained in the residue will be lost to the atmosphere, and total organic matter added to the soil will be reduced. Turning under the cover crop will speed up the decomposition and nitrogen release from the residue. In wet years, the presence of cover crop residues may increase slug damage and infections by fungal pathogens such as *Pythium* and *Rhizoctonia,* often affecting stand establishment.

3.2 Legume Cover Crops

Legumes are the best choice for increasing available soil nitrogen for crops with a high nitrogen requirement like potatoes (see Table 4.2.1). Plant in advance of the potato crop to build the soil nitrogen, or after to replace the nitrogen used by the potato crop. Legumes have symbiotic bacteria in their roots called rhizobia, which convert atmospheric nitrogen gas in the soil pores to ammonium, a form of nitrogen that plant roots can use. When the cover crop is mowed, winter killed or incorporated into the soil, the nitrogen is released and available for the next crop. Because most of this nitrogen was taken from the air, there is a net nitrogen gain to the soil (See Table 3.1). Assume approximately 50 percent of the nitrogen fixed by the cover crop will be available for the cash crop in the first season, but this may vary depending on the maturity of the legume, environmental conditions during decomposition, the type of legume grown, and soil type.

It is common to inoculate legume seed with rhizobia prior to planting, but the inoculant must be approved for use in organic systems. Request written verification of organic approval from the supplier and confirm this with your organic farm certifier prior to inoculating seed.

Special Considerations for Potato

Monitor the incidence and severity of root diseases caused by fungal pathogens (Rhizoctonia, Pythium) and nematodes (lesion, root-knot), as legumes are good hosts and will increase these pathogens if present.

3.3 Non-legume Cover Crops

Non-leguminous cover crops are beneficial because they generate organic matter, compete with weeds and help prevent soil erosion. Planted after cash crops, when the soil is still warm and microbes are releasing nitrates, they capture nitrogen that otherwise might be leached from the soil. Some non-leguminous cover crops, such as winter rye, ryegrass, brassicas and buckwheat also have been shown to reduce soil-borne diseases when used in rotation with potatoes. Potatoes grown after ryegrass or buckwheat showed significant reductions in common scab in one multi-year study in Maine. Plant these cover crops by late August.

Sudangrass and brassicas will winter-kill in the Northeast, leaving a dead mulch for cover over the winter and facilitating early spring planting. Winter hardy cover crops must be incorporated before planting, and may deplete soil moisture in dry years. If incorporated, allow two weeks or more for decomposition prior to planting.

3.4 Combining Legumes and Non-legumes

Interseeding a legume with non-legume cover crop combines the benefits of both. A quick–growing rye grown in late summer with a nitrogen-producing vetch protects the soil from heavy harvest traffic in the fall, erosion in the winter, and supplies extensive organic matter and nitrogen when incorporated in the spring. Seed rye at 50-60 lbs/acre with hairy vetch at 30 lbs/acre. Growing these cover crops together reduces the over all nitrogen contribution but helps the vetch to survive harsh winters.

Special consideration for potato

Monitor the incidence and severity of root diseases caused by fungal pathogens (Rhizoctonia, Pythium) and nematodes (lesion, root-knot), as legumes are good hosts and will increase these pathogens if present.

3.5 Biofumigant Cover Crops

Certain cover crops, when tilled into the soil as green manures and degraded by microbes, release volatile chemicals that have been shown to inhibit weeds, pathogens, and nematodes. These biofumigant cover crops include Sudangrass, sorghum-sudangrass, and many in the brassica family. Degradation is quickest when soil is warm and moist. Lightly seal the soil surface using a culti-packer or 1/2 inch of irrigation or rainwater to help trap the volatiles and prolong their persistence in the soil. Wait at least two weeks before planting a subsequent crop to reduce the potential for the breakdown product to harm the crop (phytotoxicity). This biofumigant effect is not predictable or consistent. The levels of the active compounds and ability to suppress disease can vary by season, cover crop variety, maturity at incorporation, soil microbial diversity, and microbe population density.

One Maine study showed that 'Caliente 119', a high glucosinolate mustard blend, had the most consistent effect on reducing soil borne diseases (common scab, powdery scab, stem canker and black scurf) in the subsequent potato crop. Another Maine study showed higher potato yields on fields grown after 'Caliente 119', compared to potatoes grown after barely, however white mold incidence was also higher.

Reference

Cover Crops for Vegetable Growers: Decision Tool (Reference 17).
Northeast Cover Crops Handbook (Reference 18).
Cover Crops for Vegetable Production in the Northeast (Reference 19)
Crop Rotation on Organic Farms: A Planning Manual (Reference 21).

Table 3.1 Leguminous Cover Crops: Cultural Requirements, Nitrogen Contributions and Benefits.

Species	Planting Dates	Life Cycle	Cold Hardiness	Heat (Tolerances)	Drought (Tolerances)	Shade (Tolerances)	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
Clovers											
Alsike	April-May	Biennial/ Perennial	4	5	5	6	6.3	Clay to silt	4-10	60-119	+Endures waterlogged soils & greater pH range than most clovers
Berseem	Early spring	Summer annual/ Winter annual[b]	7	6-7	7-8	5	6.5-7.5	Loam to silt	9-25	50-95	+Good full-season annual cover crop

Table 3.1 Leguminous Cover Crops: Cultural Requirements, Nitrogen Contributions and Benefits.

Species	Planting Dates	Life Cycle	Cold Hardiness	Tolerances: Heat	Tolerances: Drought	Tolerances: Shade	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
Crimson	Spring	Summer annual/ Winter annual[b]	6	5	3	7	5.0-7.0	Most if well-drained	9-40	70-130	+Quick cover +Good choice for overseeding (shade tolerant) + Sometimes hardy to zone 5.
Red	Very early spring or late summer	Short-lived perennial	4	4	4	6	6.2-7.0	Loam to clay	7-18	100-110	+Strong taproot, good heavy soil conditioner +Good choice for overseeding (shade tolerant)
White	Very early spring or late summer	Long-lived perennial	4	6	7	8	6.2-7.0	Loam to clay	6-14	$\leq$130	+Good low maintenance living cover +Low growing +Hardy under wide range of conditions
Sweet Clovers											
Annual White	Very early spring	Summer annual[b]	NFT	6-7	6-7	6	6.5-7.2	Most	15-30	70-90	+Good warm weather smother & catch crop +Rapid grower +High biomass producer
Biennial White and Yellow	Early spring-late summer	Biennial	4	6	7-8	4	6.5-7.5	Most	9-20	90-170	+Deep taproot breaks up compacted soils & recycles nutrients +Good catch crop +High biomass producer
Other Legumes											
Cowpeas	Late spring-late summer	Summer annual[b]	NFT	9	8	6	5.5-6.5	Sandy loam to loam	25-120	130	+Rapid hot weather growth
Fava Beans	April-May or July-August	Summer annual[b]	8	3	4	NI	5.5-7.3	Loam to silty clay	80-170 small seed 70-300 lg seed	71-220	+Strong taproot, good conditioner for compacted soils + Excellent cover & producer in cold soils +Efficient N-fixer
Hairy Vetch	Late August-early Sept.	Summer annual/ Winter annual	4	3	7	5	6.0-7.0	Most	20-40	80-250 (110 ave.)	+Prolific, viney growth +Most cold tolerant of available winter annual legumes
Field Peas	March-April OR late summer	Winter annual/ Summer annual[b]	7	3	5	4	6.5-7.5	Clay loam	70-220	172-190	+Rapid growth in chilly weather

NI=No Information, NFT=No Frost Tolerance. Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. a Nitrogen fixed but not total available nitrogen. See Section 8 for more information. b Winter killed. Reprinted with permission from rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook (Reference 19).

Table 3.2. Non-leguminous Cover Crops: Cultural Requirements and Crop Benefits

Species	Planting Dates	Life Cycle	Cold Hardiness Zone	Heat	Drought	Shade	pH Preference	Soil Type Preference	Seeding (Lb/A)	Comments
				--Tolerances--						
Brassicas e.g. mustards, rapeseed	April or late August-early Sept.	Annual / Biennial [b]	6-8	4	6	NI	5.3-6.8	Loam to clay	5-12	+Good dual purpose cover & forage +Establishes quickly in cool weather +Biofumigant properties
Buckwheat	Late spring-summer	Summer annual [b]	NFT	7-8	4	6	5.0-7.0	Most	35-134	+Rapid grower (warm season) +Good catch or smother crop +Good short-term soil improver for poor soils
Cereal Rye	August-early October	Winter annual	3	6	8	7	5.0-7.0	Sandy to clay loams	60-200	+Most cold-tolerant cover crop +Excellent allelopathic weed control +Good catch crop +Rapid germination & growth +Temporary N tie-up when turned under
Fine Fescues	Mid March-mid-May OR late Aug.-late Sept.	Long-lived perennial	4	3-5	7-9	7-8	5.3-7.5 (red) 5.0-6.0 (hard)	Most	16-100	+Very good low-maintenance permanent cover, especially in infertile, acid, droughty &/or shady sites
Oats	Mid-Sept-early October	Summer annual [b]	8	4	4	4	5.0-6.5	Silt & clay loams	110	+Rapid growth +Ideal quick cover and nurse crop
Ryegrasses	August-early Sept.	Winter annual (AR)/ Short-lived perennial (PR)	6 (AR) 4 (PR)	4	3	7 (AR) 5 (PR)	6.0-7.0	Most	14-35	+Temporary N tie-up when turned under +Rapid growth +Good catch crop +Heavy N & moisture users
Sorghum-Sudangrass	Late spring-summer	Summer Annual [b]	NFT	9	8	NI	Near neutral	NI	10-36	+Tremendous biomass producers in hot weather +Good catch or smother crop +Biofumigant properties

NI-No Information, NFT-No Frost Tolerance. AR=Annual Rye, PR=Perennial Rye.

Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. b Winter killed. Reprinted with permission from Rodale Institute www.rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook (Reference 19).

4. Field Selection

For organic production, give priority to fields with excellent soil tilth, high organic matter, and good drainage and airflow.

4.1 Certification Requirements

Certifying agencies have requirements that affect field selection. Fields cannot be treated with prohibited products for three years prior to the harvest of a certified organic crop. Adequate buffer zones must exist between certified organic and conventionally grown crops. The buffer zones must be a barrier such as a diversion ditch or dense hedgerow, or be a distance large enough to prevent drift of prohibited materials onto certified organic fields. Determining what buffer zone is needed will vary depending on equipment used on adjacent non-certified land. For example, use of high-pressure spray equipment or aerial pesticide applications in adjacent fields will increase the buffer zone size. Pollen from a genetically engineered plant can also be a contaminant. An organic crop should not be grown near an organic crop of the same species. Check with your certifier for specific buffer requirements.

These buffers commonly range between 20 to 250 feet depending on adjacent field practices.

4.2 Crop Rotation Plan

A careful crop rotation plan is the cornerstone of organic crop production because it allows the grower to improve soil quality and proactively manage pests. Although growing a wide range of crops complicates the crop rotation planning process, it ensures diversity in crop residues in the soil, and greater variety of beneficial soil organisms. Individual organic farms vary widely in the crops grown and their ultimate goals, but some general rules apply to all organic farms regarding crop rotation. Rotating individual fields away from crops within the same family is critical and can help minimize crop-specific disease and non-mobile insect pests that persist in the soil or overwinter in the field or field borders. Pests that are persistent in the soil, have a wide host range, or are wind-borne will be difficult to control through crop rotation. Conversely, the more host specific, non-mobile, and short-lived a pest is, the greater the ability to control it through crop rotation. The amount of time required for a crop rotation is based on the particular pest and its severity. Some particularly difficult pests may require a period of fallow. See specific recommendations in the disease and insect sections of this guide (Sections 12, 13, 15). Partitioning the farm into management units will help to organize crop rotations and ensure that all parts of the farm have sufficient breaks from each type of crop.

A well-planned crop rotation is key to weed management. Short season crops such as lettuce and spinach are harvested before many weeds go to seed, whereas vining cucurbits, with their limited cultivation time and long growing season, allow weeds to go to seed before harvest. Including short season crops in the rotation will help reduce weed populations provided the field is cleaned up promptly after harvest. Other weed reducing rotation strategies include growing mulched crops, competitive cash crops, short-lived cover crops, or crops that are intensively cultivated. Individual weed species emerge and mature at different times of the year, therefore alternating between spring, summer, and fall planted crops helps to interrupt weed life cycles.

Cash and cover crop sequences should also take into account the nutrient needs of different crops and the response of weeds to high nutrient levels. High soil phosphorus and potassium levels can exacerbate problem weed species. A cropping sequence that alternates crops with high and low nutrient requirements can help keep nutrients in balance. The crop with low nutrient requirements can help use up nutrients from a previous heavy feeder. A fall planting of a non-legume cover crop will help hold nitrogen not used by the previous crop. This nitrogen is then released when the cover crop is incorporated in the spring. See Section 3: *Cover Crops* and Section 5: *Weeds* for more information.

Rotating crops that produce abundant organic matter, such as hay and grain-legume cover crops, with ones that produce less, such as vegetables, will help to sustain organic matter levels and promote good soil tilth (see Section 2: *Soil Health* and Section 8: *Crop and Soil Nutrient Management*). Potatoes generally have a high nutrient requirement (Table 4.2.1). Growing a cover crop, preferably one that includes a legume, prior to or after potatoes will help to renew soil nitrogen, improve soil structure, and diversify soil organisms. Including short season crops in the rotation will help to reduce the overall weed population in the field.

Table 4.2.1 Crop Nutrient Requirements

	Nutrient Needs		
	Lower	**Medium**	**Higher**
Crop	Bean	Cucumber	Broccoli
	Beet	Eggplant	Cabbage
	Carrot	Brassica greens	Cauliflower
	Herbs	Pepper	Corn
	Pea	Pumpkin	Lettuce
	Radish	Spinach	Potato
		Chard	Tomato
		Squash	
		Winter squash	

From NRAES publication *Crop Rotation on Organic Farms: A Planning Manual.* Charles L. Mohler and Sue Ellen Johnson, editors (Reference 21).

Crop information specific to potatoes

Plan at least 2 years between potato crops and related crops, such as tomato and eggplant. See Cornell's minimum years to avoid specific diseases (Reference 54).

Phosphorous and potassium: Many fields with a long history of potato production have accumulated large amounts of these nutrients. Excessive levels of potash can depress specific gravity, an important factor in harvest quality. Moreover, high phosphorus and potassium levels can exacerbate problem weed species. For example, high phosphorus promotes common purslane and high potassium promotes dandelion. Removing alfalfa hay from the field for several years can reduce phosphorus and potassium levels.

Stem canker and black scurf *(Rhizoctonia solani):* Reduce canker and black scurf incidence by planting grass and cereal crops in rotation with potato or as green manure crops before potatoes. Tomato, strawberry, cabbage and Brussels sprout host canker and black scurf and will increase soil inoculum levels.

Common scab *(Streptomyces scabies)*: Use winter grain or forage grass as a green manure before potato or rotate with soybeans to reduce common scab. Avoid sweet clover as a green manure before potatoes. Rotate away from common scab hosts: beets, carrots, parsnip, radish, rutabaga and turnip.

White mold (*Sclerotinia sclerotiorum*): Beans, cabbage and Brussels sprouts host white mold and will increase soil inoculum levels.

Wireworms*:* Plant grains or grasses that are only in the field for part of the season because wireworm populations can build up in the soil if grasses are grown for an entire season or longer.

Soil structure: Root crops tend to reduce soil structure due to the additional soil disturbance during harvest; consequently, grow soil-building crops before and after a root crop.

Complementary crops: The timing of potato harvest and garlic planting are well suited for following potato with garlic.

See Table 4.2.2 for more crop rotation information specific for potatoes. For more details, see Crop Rotations on Organic Farms: A Planning Manual edited by Charles L. Mohler and Sue Ellen Johnson (Reference 21).

Table 4.2.2 Potential Interactions of Crops Grown in Rotation with Potatoes.

Crops in Rotation	Potential Effects from Rotation	Comments
Beans	White mold *increase*	Beans host white mold.
Beet, carrot, parsnip, radish, rutabaga, turnip	Common scab *increase*	These crops host common scab.
Cabbage, Brussels sprouts	Stem canker and black scurf and white mold *increase*	Cabbage and Brussels sprouts host these diseases.
Carrot, Celery	Root knot nematode *increase*	Any two-year sequence involving carrot, celery and potato should be avoided due to root-knot nematode.
Eggplant	Verticillium wilt, Colorado potato beetle and flea beetle (WT) *increase*	Eggplant hosts these pests.
Pepper	Verticillium wilt	Pepper hosts verticillium wilt.
Strawberries	Verticillium wilt, stem canker and black scurf *increase*	Strawberries host these diseases.
Tomato	Early blight, Verticillium wilt, black dot, stem canker and black scurf, Colorado potato beetle *increase*	Tomato hosts these pests.
Alfalfa	Fusarium wilt *reduction*	Alfalfa decreases Fusarium wilt.
Annual ryegrass, spring grain cover crop, Sorghum-sudangrass	Stem canker and black scurf *reduction*	Use of grasses in rotation with potato helps reduce stem canker and black scurf.
Oats, spring barley, rye, winter wheat, spelt	Stem canker and black scurf *reduction* Wireworm *increase*	One year of cereal grain in rotation with potato helps reduce stem canker and black scurf but can increase wireworm populations.
Soybean	Common scab *reduction*	Soybean before potato may reduce common scab.
Green Manures		
Winter grain cover crop as a green manure	Common scab, stem canker and black scurf *reduction*	Green manure of rye or other winter grain reduces common scab, stem canker and black scurf.
Grass and grass legume hay as a green manure	Common scab, stem canker and black scurf *reduction* Wireworm *increase*	Green manure of forage grass sod *reduces* common scab, stem canker and black scurf, but can increase wireworm populations.
Buckwheat green manure	Verticillium wilt *reduction* Soil tilth *improved*	Severity of Verticillium wilt was lower following buckwheat green manure than following canola or a fallow period; buckwheat leaves the soil in a good state of tilth for potato.
Sweet clover green manure	Common scab *increase*	Sweet clover green manure is more conducive to common scab development than alfalfa or rye.
Canola, rape and oilseed radish	General disease *reduction*	Plowed-down brassica cover crops act as a fumigant against potato diseases.

Excerpt from Appendix 2 of *Crop Rotation on Organic Farms: A Planning Manual*. Charles L. Mohler and Sue Ellen Johnson, editors (Reference 21).

4.3 Pest History

Knowledge about the pest history of each field is important for planning a successful cropping strategy. For example, avoid fields that contain heavy infestations of perennial weeds such as bindweed and quackgrass as these weeds are particularly difficult to control. One or more years focusing on weed population reduction using cultivated fallow and cover cropping may be needed before organic crops can be successfully grown in those fields. Susceptible crops should not be grown in fields with a history of Sclerotinia white mold without a rotation of several years with sweet corn or grain crops. Treat with Contans ™ to reduce fungal sclerotia in the soil immediately after an infected crop is harvested

Potatoes host both root-knot nematode, *Meloidogyne hapla*, and root-lesion nematode, *Pratylenchus penetrans*. Knowing whether these nematodes are present aids development of cropping sequences that prevent increase in uninfested or lightly infested fields and reduces populations in heavily infested fields. Refer to Section 13 for more information on nematodes.

Potatoes in close proximity to cornfields are at risk of infestation by the European corn borer. Potatoes will be especially vulnerable to egg laying if surrounding corn has not reached the mid-whorl stage during the spring flight period.

4.4 Soil and Air Drainage

Potatoes need well-drained soil to reduce the risk of pink rot and Pythium leak and powdery scab. Late blight will be less prevalent in fields with good soil and air drainage. Any practice that promotes leaf drying can slow development of foliar diseases because of the general need by pathogens for wet surfaces during infection. Fields with poor air movement such as those surrounded by hedgerows or woods are a poor choice for potatoes. Plant rows in an east-west direction and avoid overcrowding to promote drying of the soil and reduce moisture in the plant canopy.

5. Weed Management

Weed management can be one of the biggest challenges on organic farms, especially during the transition and the first several years of organic production. To be successful, use an integrated approach to weed management that includes crop rotation, cover cropping, cultivation, and planting design based on an understanding of the biology and ecology of dominant weed species. A multi-year approach that includes strategies for controlling problem species in a sequence of crops will generally be more successful than attempting to manage each year's weeds as they appear. Relying on cultivation alone to manage weeds in an organic system is a recipe for disaster.

Management plans should focus on the most challenging and potentially yield-limiting weed species in each field. Be sure, however, to emphasize options that do not increase other species that are present. Alternating between early and late-planted crops, and short and long season crops in the rotation can help minimize buildup of a particular weed or group of weeds with similar life cycles or growth habits, and will also provide windows for a variety of cover crops.

5.1 Record Keeping

Scout and develop a written inventory of weed species and severity for each field. Accurate identification of weeds is essential. Weed fact sheets provide a good color reference for common weed identification. See Cornell weed ecology and Rutgers weed gallery websites (References 24- 25)

5.2 Weed Management Methods

Planting and cultivation equipment should be set up on the same number of rows to minimize crop damage during cultivation. Specialized equipment may be needed to successfully control weeds in some crops. See resources at the end of this section to help fine-tune your weed management system.

For optimal weed management in potatoes, plan several seasons ahead. Do not plant potatoes in a field infested with quackgrass, which can damage tubers. Eliminate quackgrass and other perennial weeds and reduce the seed bank of annual weeds (1) by growing crops that require intensive cultivation, (2) by growing short season crops and cleaning up the field quickly after harvest, and (3) by using cultivated fallow periods.

Before planting potatoes, incorporate any growing weeds completely using a moldboard plow, spader or rotary tiller. When planting, ensure that the seed pieces are well covered. The surface after planting should be flat or have an inch or two of extra soil over the rows. If soil is mounded on top of seed pieces that are planted near the soil surface, tine weeding will probably uncover the seed. Placing extra soil over the rows with the planter ensures that the seed remains covered and guarantees aggressive action by the tine weeder as it knocks the extra soil into the shallow valleys

Tine weed every 5-7 days until potatoes emerge and again when the shoots are 4-6". At least one pre-emergence and one post-emergence tine weeding will be needed. An optimal tine weeder for potatoes will have stiff tines with a 45-degree bend. Tines should be set so that they do not hit the seed pieces. In particular, check to ensure that no seed pieces are flipped out of the ground by the weeder. Set the tines to run ½ to ¾" above the seed and move at 3-4 mph for optimal weed control.

If a tine weeder is used as recommended above, begin inter-row cultivation when plants are about 12-15" tall. At the first cultivation, heap 2"-3" of soil around base of plants in the row to bury small seedlings. Soil can be moved into the crop row either with disk hillers or with sweeps that have a relatively steep angle. The goal is to have the highest point of the soil in the line of the crop, rather than a dip in the middle where weeds remain uncovered. If potatoes are growing slowly, an additional cultivation might be needed. Most likely, the next operation will be hilling. If a tine weeder is not available, begin inter-row cultivation when the first flush of weeds has emerged, regardless of whether the potatoes are up yet. Throw sufficient soil into the row to completely cover weed seedlings. Repeat for each successive flush of weeds until the final hilling."

A standard hilling operation will usually cover any additional seedlings that have emerged. After hilling, the potato plants are usually too large to cultivate again, but sometimes an extra cultivation between the rows will be useful.

Between hilling and harvest, rogue out any large weeds that get established: In doing so, you will (1) prevent seed set that could pose problems for rotation crops (2) eliminate possible virus hosts and (3) avoid the development of very large weeds that can jam up the potato digger. Rogueing out large weeds may require less labor than cleaning out the digger when it becomes jammed.

Before harvest mow the vines. This will not only make digging the potatoes easier, but will also decrease the likelihood of weeds going to seed. Many weeds that have already flowered will continue to set seeds even if they have been completely uprooted and left on the soil surface. Some growers flame the residue after mowing to speed drying and kill fungal spores that might infect the tubers. This has the additional benefit of further reducing seed production, for example, by short weeds between the hills and by pieces of pigweed flowering stalks.

References

Crop Rotation on Organic Farms: A Planning Manual (Ref 21)
Steel in the Field e-book (Reference 23)
Cornell Weed Ecology website (Reference 24)
New Jersey Weed Gallery (Reference 25)
Principals of sustainable weed management for croplands (Ref 27)
New cultivation tools for mechanical weed control in vegetables (Reference 28)
Weed 'Em and Reap videos (Reference 29)
Flame weeding for vegetable crops(Reference 30)
Vegetable farmers and their weed control machines video (Refce eren31).

6. RECOMMENDED VARIETIES

Variety selection is important both for the horticultural characteristics specified by the market and the pest resistance profile that will be the foundation of a pest management program. If disease pressures are known, Table 6.1.2 can help to determine which varieties will be more successful in reducing disease problems. Consider the market when choosing varieties, selecting those with some level of disease resistance if possible.

A certified organic farmer is required to plant certified organic seed. If, after contacting at least three suppliers, organic seed is not available for a particular variety, then the certifier may allow untreated conventional seed to be used.

Table 6.1.1 Cultural characteristics of potato varieties.

Variety	Skin color/ flesh color[2]	Maturity[3]	Tuber set [4]	Ave tuber weight [4]	Use[5]	Nitrogen required mineral soils	Nitrogen required muck soils	Organic Marketable Yield	Conventional marketable yield	Specific gravity[4]	External defects[4]	External defects[4]	Internal defects[4,10]	Internal defects[4,10]	Dormancy[11]
		Relative to Atlantic	#Tubers/ foot	Oz.		N lbs/A[6]	N lbs/A[6]	CWT/A	CWT/A	1.0xx[9]	%	Defects	%	Defects	
Adirondack Blue[1]	P/P	EM	6.7	4.3	T	125-150	80	160	205	73	12	knobs	2	VD	-4[b]
Adirondack Red[1]	R/R		9.2	3.4	T	125-150	80	180	216	67	5	green	3	VD	+10[b]
All Blue[1]	P/P	ML			T	100-125	80	120	210						+13[b]
Allegany	W/W	L			T	100-125	60	70	315						+48
Andover	W/W	EM	7.3	5.2	C,T	125-150	100	135	280	83	3	green	2	HH	+22[a]
Atlantic[7]	Bu/W	M	7.7	5.5	C	100-125	80	230	325	92	4	green	9	HH	0(std)
Austrian Crescent[1]	Bu/Y	L			T										
Bake-King		M			T										
Banana[1]	Y/Y	L			T										
Caribe[1]	RP/W	E			T										
Carola[1]	Y/Y	M	10	4.2	T	100-125	80	195	290	76	6	green	23	VD	+11
Chieftan[1]	R/W	M	8.8	6.2	T	100-125	80	270	335	71	4	green	6	VD	0(std)[b]
Elba[1]	Bu/W	VL			T	100-125	60	190	330						
Eva[1]	W/W	M	7.6	5.3	C,T	125-150	100	195	310	77	6	green	2	VD	+43
French Fingerlings[1]	R/Y				T										
Genesee	W/W	L	7.1	5.3	T	100-125	80	135	285	71	7	green	5	VD	-10
German Butterball[1]	Y/Y	L			T			70	250						
Green Mountain	W/W					100-125	80	220	185						
Kanona	W/W	ML			C	125-150	80		305						
Katahdin[1]	Bu/W	L	7.4	5.6	T	100-125	80	205	300	75	9	green	8	HH	+5
Kennebec[1]	W/W	ML			C,T	100-125	80		265						+27

Table 6.1.1 Cultural characteristics of potato varieties.

Variety	Skin color/ flesh color[2]	Maturity[3]	Tuber set [4]	Ave tuber weight [4]	Use[5]	Nitrogen required mineral soils	Nitrogen required muck soils	Organic Marketable Yield	Conventional marketable yield	Specific gravity[4]	External defects[4]	External defects[4]	Internal defects[4,10]	Internal defects[4,10]	Dormancy[11]
		Relative to Atlantic	#Tubers/ foot	Oz.		N lbs/A[6]	N lbs/A[6]	CWT/A	CWT/A	1.0xx[9]	%	Defects	%	Defects	
Keuka Gold[1, 8]	Y/Y	ML	9.9	5.1	T	100-125	80	225	400	76	4	green	8	VD	+7
King Harry	W/W				T	125-150	100	235	325						-5[a]
LaRatte[1]	Bu/Y	L			T										
Lehigh[1]	Bu/Y	ML	7.1	5.8	T	125-150	100	175	315	81	5	green	6	VD	+6
Marcy	Bu/W	L			C	80-100	60	120	385						+23
Monona	W/W	M			C,T	125-150[7]	100[7]		275						
Norland[1]	R/W	EM			T	125-150[7]	100[7]	160	265						-20[b]
Norwis	W/W	ML			C,T	100-125	80		370						
Ozette[1]					T										
Pike[8]	W/W	ML			C	100-125	80		310						
Purple Viking[1]	P/W	M			T										
Reba	W/W	M	7.4	5.6	C,T	100-125	80	140	325	76	4	green	4	HH	+20
Red Gold[1]	R/Y				T				175						
Red Norland	R/W		8.7	4.1	T	100-125	100	160	265	64	3	cracks	7	VD	-20[b]
Reddale[1]					T				270						
Redsen	R/W	E			T	125-150[7]	100[7]		220						
Rose Finn Apple[1]	R/Y				T										
Salem[1]	W/W	M	8.6	5.3	T	100-125	80	210	345	69	4	green	9	VD	+12
Snowden	Bu/W	VL			C,T	100-125	80								+3
Superior[1]	Bu/W	E	6.5	5.0	T	125-150[7]	100[7]	170	270	76	4	knobs	9	VD	0(std)[a]
Yellow Finn[1]	Y/Y	M			T			30							
Yukon Gold[1]	Y/Y	M		6.6	T	100-125	80	180	285						+4[a]

1. Varieties commonly grown by organic growers. **2**. W = white; Bu = buff white; R = red; Y = yellow; P = purple; B = blue, F= fingerlings**3**. Maturity relative to Atlantic: E = early; EM = early to medium; M = medium; ML = medium to late; L = late; VL = very late **4**. Adapted from Potato Cultural Guide table, John Mishanec, Don Halseth, Tom Zitter, Walter De Jong, Helen Griffiths and Ward Tingey.

5. Use: T = tablestock; C = chipstock. **6.** Nitrogen recommendations based on target yield for each variety. (mineral soil: H= 125-150 lb/ac., M= 100-125lb/ac, L= 80-100 lb/acre and muck soil: H= 100 lb/ac., M= 80 lbs/ac., L= 60 lbs/ac.) If you frequently get 300 cwt/a on a variety, increase the recommended rates in the table by 15%. **7.** If an early harvest is desired reduce N applied by 25 to 33 percent. **8.** May have internal necrosis in susceptible production areas. **9.** The numbers in this column are the last two digits (xx) of the specific gravity value. **10.** Internal Defects: Vd= vascular ring; HH=hollow heart; cracks= growth cracks. **11.** Dormancies are all compared in days (+ = longer, - = shorter) to Atlantic except for: a = Dormancy compared to Superior; b = Dormancy compared to Chieftain.

Table 6.1.2 Disease, nematode and insect resistance of potato varieties.

Variety[1]	Black dot	Early blight	Golden nematode race 01	Late blight[2]	Pink rot[3]	Scab[7]	Silver scurf[3]	Verticillium wilt	Leaf-hopper[6]	Colorado potato beetle[6]
Adirondack Blue[1]				S	S	MS	S		S	S
Adirondack Red[1]			S		S	MS	S		S	S
All Blue[1]									S	
All Red									MR	
Allegany		R	R		R^{Field} MS/S^{GH}	MR		R	S	S
Andover	MS/S	S	R	S	R/MR	MR			S	S
Atlantic[2]		MR	R	S	R/MR	MR		T	MS	MS
Austrian Crescent[1]					S					
Bake King						S			S	
Banana[1]	MS/S				R	R			S	
Butte					S				S	
Caribe[1]						M				
Carola[1]			S	M		T			S	MS
Chieftan[1]	MS	MR	S	S	MS	MR	MS		S	S
Elba[1]		R	R	R		R		R	MR	MR
Eva[1]	R/MR	M	R	S	R^{Field} S^{GH}	MR	MS		MS	MS
French Fingerlings[1]									S	
Genesee	MR	MR	R	S	S	MR		R	S	S
German Butterball[1]					S					
Green Mountain									MS	S
Kanona			R			VS			S	S
Katahdin[1]		MR	S	MS		S			MR	MS
Kennebec[1]			S	R		VS[4]			S	MS
Keuka Gold[1, 5]	R/MR		R	S	R/MR	R			MS	S
King Harry					R				R	MR
LaRatte[1]										
Lehigh[1]	MR		R		S	VR			S	S
Marcy			R		MR	MR				
Monona	MS/S		S		MS	MR			MS	S

Table 6.1.2 Disease, nematode and insect resistance of potato varieties.

Variety[1]	Black dot	Early blight	Golden nematode race 01	Late blight[2]	Pink rot[3]	Scab[7]	Silver scurf[3]	Verticillium wilt	Leaf-hopper[6]	Colorado potato beetle[6]
Norland[1]	MR		S		MS/S	R				
Norwis (FL 657)	MR		S		MR[GH] S[Field]	VS			MS	S
Ozette[1]										
Pike[1,5]	MS/S		R		MR	R				
Prince Hairy										R
Purple Viking[1]										
Reba	MS/S	MR	R	S	MS/S	MR		MR	S	S
Red Gold[1]										
Red Norland	MR	VS	S	S	S[3]	T			S	S
Reddale[1]										
Redsen			S			MR			S	S
Rose Finn Apple[1]										
Salem[1]		MR	R	S		VR			S	MS
Snowden			S		MR	MS			MS	S
Superior[1]	MS	VS	S	S	R/MR[3]	R		VS	S	S
Yellow Finn[1]										
Yukon Gold[1]	MS	S	S	S	MS/S[Field3]	S	MS		MR	S

1. Varieties commonly grown by organic growers. **2.** All potato varieties should be considered susceptible to late blight. **3.** Adapted from: Potato Cultural Guide table John Mishanec, Don Halseth, Tom Zitter, Walter De Jong, Helen Griffiths and Ward Tingey. Reactions to pink rot will vary depending on whether rating is based on tuber infection in the field (Field) or on tubers recovered from plants infected in the greenhouse (GH). See Reference 45 for more information on pink rot susceptibility.

4. From: Pest Management Strategic Plan for Organic Potato Production in the West, Summary of workshops held on February 16, 2006 (Reference 5).

5. May have internal necrosis in susceptible production areas. 6. VR = very resistant; R = resistant; MR = moderately resistant; T = tolerant; MS = moderately susceptible; S = susceptible; or VS = very susceptible. **7.** No varieties should be considered immune to scab. In a very dry year, varieties can perform badly regardless of rating.

Table 6.1.3 Potato Variety Culinary Use Guide.

Variety	Distinct flavor	Texture	Baked	Boiled	Fried	Mashed	Potato salad	Turns gray after boiling	Firmness after boiling	Yield peeled	IPM friendly	Comments and remarks
Adirondack Blue[1]	Yes	Med	Moist	Loses color	No	Good	Good	No	Excellent	Low		Beautiful dark blue colored flesh, irregular shapes
Adirondack Red[1]		Med	Moist	Loses color	No	Good	Good	a little	Excellent	Good		Uniform shape, unique red colored flesh
Andover	Yes	Dry	Dry	Good	Yes	Fair	Fair	a little	Good	Mod	Yes	Dry fluffy baked, good for French fries, high starch
Atlantic		Dry	Dry	Poor	Yes	Poor	poor	a little	Poor	Good	Yes	Very dry baked potato, high starch
Carola[1]	Yes	Moist	Moist	Waxy	No	Excellent	Excellent	No	Excellent	Good		Bright yellow flesh, very moist, firm after boiling
Chieftan[1]		Moist	Moist	Excellent	No	Excellent	Excellent	No	Good	Mod		Good eating qualities, widely grown red
Eva[1]		Med	Inter-mediate	Good	Yes	Good	Good	a little	Good	High	Yes	Shallow eyes, smooth bright skin, uniform shape
Genesee		Med	Inter	Good	Ok	Good	Good	a little	Good	Good	Yes	Attractive round white, all purpose
Katahdin[1]		Med	Moist	Good	No	Excellent	Excellent	a little	Good	Mod	Yes	An old standard variety, round white
Keuka Gold[1]	Yes	Med	Inter	Good	Yes	Good	Good	a little	Good	Mod	Yes	Like Yukon Gold, from NY and very good eating qualities
Lehigh[1]		Med	Inter	Good	Yes	Good	Good	no	Good	Good	Yes	Round yellow flesh, firm after boiling, a new all purpose variety
Reba		Med	Inter	Good	Yes	Good	Good	a little	Good	Mod	Yes	Large, attractive bright white flesh, firm after boiling
Red Norland		Moist	Moist	Excellent	No	Excellent	Excellent	a little	Good	Mod		Darker in color than Chieftain, widely grown red, round
Salem[1]	Yes	Med	Inter	Good	Ok	Good	Good	a little	Good	Good		Round white, excellent flavor
Superior[1]		Med	Inter	Good	Yes	Superior	Excellent	a little	Good	Low		Very early, round white, irregular shapes

Adapted from Potato Variety Culinary Use Guide. John Mishanec, Don Halseth and Walter De Jong, Cornell University.

1. Varieties commonly grown by organic growers.

7. Planting Methods

7.1 Seed Sources

A certified organic farmer is required to plant certified organic seed and is strongly advised to also plant only phytosanitary certified seed. If organic seed is not available in the preferred varieties, check with organic certifier to determine options.

While it may seem advantageous for organic growers to save their own seed, it is not recommended. Diseased seed not only affects the plants that grow from it but also puts the rest of the field and the whole farming operation at risk because cutters, planters, and other equipment can spread many diseases. In the case of late blight, diseased plants from affected seed tubers serve as the primary inoculum source from which other plants in the field can be infected as the inoculum is spread by wind, rain, and insect activity. This is the same risk posed by leaving cull piles exposed in the vicinity of production fields. A grower often cannot tell by looking at tubers whether they will be good for seed.

See the New York seed directory, Maine seed directory, and the Colorado seed directory (References 32-34) for more information about the certification program, varieties and lists of phytosanitary certified seed suppliers. Carefully inspect seed at the time of receipt. If possible, evaluate the seed before it is shipped. For a guide to potato seed evaluation, see Reference 55.

7.2 Seed Preparation and Handling

When handling seed, growers should maintain lot identity and prevent contamination. Trucks, storage, and handling equipment must be clean and disinfected (see Table 10.3.1) between each lot of certified seed. Seed tubers should be stored at 38°F and high humidity to prevent premature sprouting and dehydration. Physiological disorders that result from lack of oxygen and excessively cold temperatures during storage or transit contribute to seed piece problems and poor stand establishment.

Optimum seed will have medium to young physiological age. Factors that contribute to aging of potato seed include temperature, stress, physical damage to tubers, and other factors influencing seed during growth and storage. While old seed will sprout earlier, it will have more stems, higher tubers set, smaller tuber size and less vigor. Young seed will take longer to sprout, have fewer stems, larger tubers and more vigor. It is difficult to visually determine physiological age of seed, but a simple test will give some idea: warm up (55-60 F) a sample of potatoes in mid-winter and observe how quickly they sprout. The longer a seed lot takes to sprout, the younger the seed.

Tubers should be warmed to 50° to 60°F before being handled or cut. If not using whole seed, precut and heal seed before planting. Curing cut seed (suberization) is best accomplished by placing seed in half-full pallet boxes or spread out in piles only a few feet deep with adequate air circulation, temperature between 55° and 60°F, and about 90 percent relative humidity. After cut seed has been held at optimal curing conditions for one week, the storage temperature should be lowered to between 40° and 45°F to maintain vigor and avoid excessive sprout growth. Seed should be warmed to 50 to 55F for 7 to 14 days before planting.

Green sprouting or "pre-sprouting," is the practice of exposing seed potatoes to conditions that promote numerous uniform, stubby, dark green sprouts that emerge quickly after planting. Potatoes thus treated may be harvested early and may avoid late blight and other insects and diseases that develop later in the season. Healing (suberizing) and greensprouting require different conditions and need to be done sequentially for best results. Green sprouting is more practical for hand planting. Read more about this in the Maine Organic Farmers and Gardeners Association newsletter. (Reference 35).

For most varieties grown in New York State, seed weight of 1.5 to 2 ounces is optimal. Cut seed should be blocky in shape to reduce the cross-sectional area and facilitate uniform planting by equipment. Mechanical seed cutters should be adjusted to seed size and shape, and seed should be graded to a uniform size before cutting. See Table 7.2.1.

Table 7.2.1 Potato seed (cwt) required to plant one acre.

Distance between seed in row	34" between rows Weight of seed pieces (oz)				36" between rows Weight of seed pieces (oz)			
	1	1.5	1.75	2	1	1.5	1.75	2
inches	cwt							
6	19	29	34	38	18	27	32	37
8	14	22	25	29	14	20	24	27
10	11	17	20	23	11	16	19	22
12	10	14	17	19	9	14	16	18
15	8	11	14	16	7	11	13	14

7.3 Planting

To encourage quick emergence and robust development, plant seed pieces at 4-6" depth into well drained soil as soon as soil is warm enough, and cultivate lightly. This favors plant development over disease development and creates vigorous plants that are better able to withstand early season feeding by Colorado potato beetle and flea beetles.

Biological seed treatments such as products containing *Trichoderma harzianum* and *Streptomyces griseoviridis* are not substitutes for disease-free seed or good sanitation and handling, but can reduce losses from disease when cut seed is held before planting or is planted into cold, wet soil. It can also prevent the introduction into non-infested soils of surface-borne organisms that cause diseases such as

Rhizoctonia black scurf and stem canker. These products require good soil moisture to activate the organisms. Check individual disease sections below for rates and more information.

Some growers have reduced seed piece decay by applying untreated finely ground fir bark to cut seed pieces. Fir bark enhances suberization by holding humidity at the cut seed surface and also prevents seedpieces from sticking together and then pulling apart, which can create open wounds on healed surfaces. Fir bark allows better seed movement through the planter. Always check with your certifier before using any product to be sure it is approved.

Once plants emerge one to several hilling operations are useful for weed control and providing more soil to minimize tuber greening. Hill when plants are 6 to 12 inches tall, before row closes, to avoid damaging roots and tops. Timely tillage improves the physical condition of the soil, which helps plant roots explore the soil profile, controls weeds, and incorporates organic materials. However, excessive tillage destroys soil structure and compacts the ground, besides wasting fuel. Working the soil when too wet can also destroy soil structure and compact the land.

8. Crop & Soil Nutrient Management

To produce a healthy crop, sufficient soluble nutrients must be available from the soil to meet the minimum requirements for the whole plant. The total nutrient needs of a crop are much higher than just the nutrients that are removed from the field when that crop is harvested. All of the roots, stems, leaves and other plant parts require nutrients at specific times during plant growth and development. Restrictions in the supply of required plant nutrients will limit growth and reduce crop quality and yields.

The challenge in organic systems is balancing soil fertility to supply these required plant nutrients at a time and at sufficient levels to support healthy plant growth. Soil microbes decompose organic matter to release nutrients and convert organic matter to more stable forms such as humus. This breakdown of soil organic matter occurs throughout the growing season, depending on soil temperatures, water availability and soil quality. The released nutrients are then held on soil particles or humus making them available to crops or cover crops for plant growth. Amending soils with compost, cover crops, or crop residues also provides a food source for soil microorganisms and when turned into the soil, starts the nutrient cycle again.

During the transition years and the early years of organic production, soil amendment with composts or animal manure can be a productive strategy for building organic matter, biological activity and soil nutrient levels. This practice of heavy compost or manure use is not, however, sustainable in the long-term. If composts and manures are applied in the amounts required to meet the nitrogen needs of the crop, phosphorous may be added at higher levels than required by most vegetable crops. This excess phosphorous will gradually build up to excessive levels, increasing risks of water pollution or invigorating weeds like purslane and pigweed. A more sustainable, long-term approach is to rely more on legume cover crops to supply most of the nitrogen needed by the crop and use grain or grass cover crops to capture excess nitrogen released from organic matter at the end of the season to minimize nitrogen losses to leaching. See Section 3: *Cover Crops*. When these cover crops are incorporated into the soil, their nitrogen, as well as carbon, feeds soil microorganisms, supporting the nutrient cycle. Harvesting alfalfa hay from the field for several years can reduce high phosphorus and potassium levels.

Some soils are naturally high in P and K, or have a history of manure applications that have resulted in elevated levels. Regular soil testing helps monitor nutrient levels, in particular phosphorus (P) and potassium (K). Choose a reputable soil-testing lab (Table 8.0.1) and use it consistently to avoid discrepancies caused by different soil extraction methods. Maintaining a soil pH between 6.3 and 6.8 will maximize the availability of all nutrients to plants.

To assess overall impact of organic matter additions on soil health, consider selecting a few target or problem fields for soil health monitoring over time via the Cornell Standard Soil Health Analysis Package. This suite of eight tests complement a standard soil chemical nutrient analysis by focusing on biological and physical soil health indicators. While the test results will provide feedback on how the soil sample compares to other New York soils, the real power is in the baseline readings for comparison in the future after implementing new soil health and nutrient management strategies.

Table 8.0.1 Nutrient Testing Laboratories.

Testing Laboratory	Soil	Compost/ Manure	References
The Agro One Lab (Cornell Recommendations)	x	x	40
Agri Analysis, Inc.		x	36
A&L Eastern Ag Laboratories, Inc.	x	x	37
Cornell Soil Nutrient Analysis Lab	x		16
Penn State Ag Analytical Services Lab.	x	x	38
University of Massachusetts	x	x	39
University of Maine	x	x	41

8.1 Fertility

Recommendations from the Cornell Integrated Crop and Pest Management Guidelines indicate that on mineral soils an organic potato crop requires 150 lbs. of available nitrogen (N), 200 lbs. of phosphorus (P) and 200 lbs. of potassium (K) per acre. On muck soils, a potato crop requires 100 lbs. of available nitrogen (N), 80 lbs. of phosphorous (P) and 80 lbs. of potassium (K) per acre. These values are factored for an anticipated yield of 250-hundredweight organic potatoes per acre. If you regularly yield 300 hundredweight per acre, increase nutrient values by 15%. See Table 8.2.2 for the recommended application rates of nitrogen, phosphorus, and potassium. Nitrogen requirements increase with the length of time to harvest. Use knowledge of variety and nutrient potential of the soil to estimate yield potential, then adjust nutrient applications accordingly. Good record keeping on cultural practices including variety and fertility management and subsequent yield will help with decision making in future years.

Soils should be tested frequently for nutrient levels and pH. Many fields with a long history of potato production have accumulated large amounts of potassium (potash) and phosphorus. While high levels of potash can reduce internal defects such as hollow heart and brown center, it can depress specific gravity, an important factor in processing quality.Some soils are naturally high in P and K, or have a history of manure applications that have resulted in elevated levels. More nitrogen and phosphorus may be available from soils in fields under organic production, where cover crops are commonly used, than in soils under conventional tillage. N is slowly and continuously released from OM. Excess soil nitrogen can cause poor skin condition, delay maturity, affect storage, and increase Fusarium and Pythium incidence. If maturity is delayed, postpone harvest if possible, especially of red potatoes, which skin easily when not mature and can suffer water loss. When fields are harvested later, they are at increased risk from Colorado potato beetles and late blight. Excess nitrogen and phosphorous can also contaminate ground water and surface run off.

Maintaining a soil pH between 6.3 and 6.8 will maximize the availability of beneficial nutrients to plants. Low soil pH reduces the availability of phosphorus and increases the availability of toxic elements such as iron and aluminum. However, to control common scab, soil pH should be kept within a relatively narrow range (5.0 to 5.2). If scab-resistant varieties are used, potatoes can be grown in soil with pH levels near 6.0, increasing the availability of phosphorus and other soil nutrients.

All lime and fertilizer recommendations should be based on soil test history. Mineral soils should have pH determined in calcium chloride and should have measurements made of iron, aluminum, and manganese in addition to the traditional measurements of phosphorus (P), potassium (K), and magnesium (Mg). If soil magnesium is below 100, apply 190 pounds of magnesium sulfate per acre (30 lb magnesium per acre).

Many types of organic fertilizers are available to supplement the nutrients supplied by the soil. **ALWAYS check with your certifier before using any product to be sure it is approved**.

8.2 Preparing an Organic Nutrient Budget

To create a robust organic fertility management plan, develop a plan for estimating the amount of nutrients that will be released from soil organic matter, cover crops, compost, and manure. As these practices are integrated into field and farm management, the goal is to support diverse microbial communities that will help release nutrients from the organic matter additions.

Remember that with a long-term approach to organic soil fertility, the N mineralization rates of the soil will increase. This means that more N will be available from organic amendments because of increased soil microbial activity and diversity. Feeding these organisms different types of organic matter is essential to building this type of diverse biological community and ensuring long-term organic soil and crop productivity. Included in the Soil Health Test is an analysis of soil protein content. As with the other soil health tests, this serves as an indicator of soil management and amendment history. The test measures organic soil N that is in the form of proteins- an important food source for soil microbes. Use this test to help monitor impact and target future investments of legume cover crops and compost / manure applications.

Estimating total nutrient release from the soil and comparing it with soil test results and recommendations requires record-keeping and some simple calculations. Table 8.2.1 below can be used as a worksheet for calculating nutrients supplied by the soil compared to the total crop needs. Table 8.2.3 estimates common nutrient content in animal manures; however actual compost and manure nutrient content should be tested just prior to application. Analysis of other amendments, as well as cover crops, can be estimated using published values (see Tables 8.2.4 to 8.2.6 and 3.1 for examples). Keeping records of these nutrient inputs and subsequent crop performance will help evaluate if the plan is providing adequate fertility during the season to meet production goals.

Table 8.2.1 Calculating Nutrient Credits and Needs.

	Nitrogen (N) lbs/A	Phosphate (P_2O_5) lbs/A	Potash (K_2O) lbs/A
1. Total crop nutrient needs			
2. Recommendations based on soil test	Not provided		
3. Credits			
a. Soil organic matter		---	---
b. Manure			
c. Compost			
d. Prior cover crop			
4. Total credits:			
5. Additional needed (2 – 4 =)			

Line 1. Total Crop Nutrient Needs: Agricultural research indicates that a potato crop on mineral soil requires 120-175 lbs. nitrogen (N), 240 lbs. phosphorus (P), and 240 lbs. potassium (K) per acre to support an average yield (see Section 8.1: *Fertility* above and Table 6.1.1 for varietal nitrogen requirements).

Line 2. Recommendations Based on Soil Test: Use Table 8.2.2 to determine the amount of P and K needed based on soil test results.

Table 8.2.2 Potato crop nutrient needs based on soil tests. (Factored for 250 hundred weight yield; reduce for lower yields[1])								
	N Level	**Soil Phosphorus Level**			**Soil Potassium Level**			
Level shown in soil test	Not available	Low	med	high	low	med	high	Very high
Total nutrient recommendation	**N lbs/A[2]**	**P_2O_5 Pounds/A[3]**			**K_2O Pounds/A**			
Mineral soils	100-150	200	150	100	200	100	62	50
Muck soils	60-100	80	60	40	80	65	50	50

1. Use knowledge of variety and field to estimate yield, then adjust nutrient applications accordingly. If you frequently get 300 cwt/a on a variety, increase the recommended rates in the table by 15%.

2. Apply 50- lb N/A in bands at planting, and then apply remainder when plants are 4-8 inches tall. Reduce N rate by 50 to 75 lb/A if a good stand of clover or alfalfa is plowed down. Adjust N rate to suit variety grown (see Table 6.1: *Cultural characteristics of Potato Varieties*).

3. If pH levels are below 5.2 or iron plus aluminum levels are above 200, apply 20 lb phosphate/A regardless of soil phosphate level. Banded phosphate is more available than broadcast applications.

Line 3a. Soil Organic Matter: Using the values from your soil test, estimate that 20 lbs. of nitrogen will be released from each percent organic matter in the soil. For example, a soil that has 2% organic matter could be expected to provide 40 lbs N per acre

Line 3b. Manure: Assume that applied manure will release N for three years. Based on the test of total N in any manure applied, estimate that roughly 50% is available to the crop in the first year, and then 50% of the remaining is released in each of the next two years. So, for an application rate of 100 lbs. of N as manure, in year one 50 lbs. would be available, 25 lbs. in year 2, and 12.5 lbs. in year 3. Remember to check with your certifier on the days-to-harvest interval when using raw manure and allow a minimum of 120 days between application and harvesting. Enter estimated phosphorous additions and be aware that some manures have high phosphorous content (Table 8.2.3). Assume about 80% of the phosphorous and 90% of the potassium to be available in the first year.

Remember, any raw manure applications must occur at least 120 days before harvest of a vegetable crop.

Line 3c. Compost: Estimate that between 10 to 25% of the N, , 80% of the phosphorous and 90% of the potassium contained in most composts is available to the crop the first year. It is important to test each new mix of compost for actual amounts of the different nutrients available. Compost maturity will influence how much N is available. If the material is immature, more of the N may be available to the crop in the first year. A word of caution: Using compost to provide for a crop's nutrient needs is not generally a financially viable strategy. The high total volume needed can be very expensive for the units of N available to the crop, especially if trucking is required. Most stable composts should be considered as soil conditioners, improving soil health, microbial diversity, tilth, and nutrient retaining capacity. Also keep in mind that manure-based composts are potentially high in salts that could become a problem if used yearly. Most compost analyses include a measure of electrical conductivity which indicates level of salts present in the finished product. Any compost applied on organic farms must be approved for use by the farm certifier. Compost generated on the farm must follow an approved process outlined by the certifier.

Line 3d. Cover Crops: Estimate that 50 percent of the fixed N is released for plant uptake in the current season when incorporated. Consult Table 3.1 to estimate the amount of N fixed by legume cover crops.

Line 4. Total Credits: Add together the various nutrient values from soil organic matter, manure, compost, and cover crops to estimate the nutrient supplying potential of the soil (see example below). There is no guarantee that these amounts will actually be available in the season, since soil temperatures, water, and crop physiology all impact the release and uptake of these soil nutrients. If the available N does not equal the minimum requirement for this crop, a sidedress application of organic N may be needed. There are several options for N sources for organic side dressing (see Table 8.2.4) as well as pelleted composts. Early in the organic transition, a grower may consider increasing the N budget supply by up to 25%, to help reduce some of the risk of N being limiting to the crop.

Table 8.2.3 includes general estimates of nutrient availability for manures and composts but these can vary widely depending on animal feed, management of grazing, the age of the manure, amount and type of bedding, and many other factors. See Table 3.1 for estimates of the nitrogen content of various cover crops.

Table 8.2.3 Estimated Nutrient Content of Common Animal Manures and Manure Composts.

	Total N	P_2O_5	K_2O	N1 [1]	N2 [2]	P_2O_5	K_2O
	Nutrient content lb/ton			*Available nutrients lb/ton in first season*			
Dairy (with bedding)	9	4	10	6	2	3	9
Horse (with bedding)	14	4	14	6	3	3	13
Poultry (with litter)	56	45	34	45	16	36	31
Composted dairy manure	12	12	26	3	2	10	23
Composted poultry manure	17	39	23	6	5	31	21
Pelleted poultry manure [3]	80	104	48	40	40	83	43
Swine (no bedding)	10	9	8	8	3	7	7
	Nutrient content lb/1000 gal.			*Available nutrients lb/1000 gal first season*			
Swine finishing (liquid)	50	55	25	25[a]	20+	44	23
Dairy (liquid)	28	13	25	14 [a]	11+	10	23

1-N1 is the estimated total N available for plant uptake when manure is incorporated within 12 hours of application. 2-N2 is the estimated total N available for plant uptake when manure is incorporated after 7 days. 3. Pelletized poultry manure compost. Available in New York from Kreher's. a injected, + incorporated. Adapted from *Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops* by Carl Rosen and Peter Bierman (Reference 42) and Penn State Agronomy Guide 2015-6 (Reference 42A).

Tables 8.2.4-8.2.6 list some commonly available fertilizers, their nutrient content, and the amount needed to provide different amounts of available nutrients.

Table 8.2.4 Available Nitrogen in Organic Fertilizer.

	Pounds of Fertilizer/Acre to Provide X Pounds of N Per Acre				
Sources	**20**	**40**	**60**	**80**	**100**
Blood meal, 13% N	150	310	460	620	770
Soy meal 6% N (x 1.5) [a] also contains 2% P and 3% K_2O	500	1000	1500	2000	2500
Fish meal 9% N, also contains 6% P_2O_5	220	440	670	890	1100
Alfalfa meal 2.5% N also contains 2% P and 2% K_2O	800	1600	2400	3200	4000
Feather meal, 15% N (x 1.5) [a]	200	400	600	800	1000
Chilean nitrate 16% N cannot exceed 20% of crop's need.	125	250	375	500	625

[a] Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil-testing lab (Reference 41).

Table 8.2.5 Available Phosphorous in Organic Fertilizers.

	Pounds of Fertilizer/Acre to Provide X Pounds of P_2O_5 Per Acre				
Sources	**20**	**40**	**60**	**80**	**100**
Bonemeal 15% P_2O_5	130	270	400	530	670
Rock Phosphate 30% total P_2O_5 (x4) [a]	270	530	800	1100	1300
Fish meal, 6% P_2O_5 (also contains 9% N)	330	670	1000	1330	1670

[a] Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil-testing lab (Reference 41).

Table 8.2.6 Available Potassium in Organic Fertilizers.

	POUNDS OF FERTILIZER/ACRE TO PROVIDE X POUNDS OF K_2O PER ACRE:				
SOURCES	**20**	**40**	**60**	**80**	**100**
Sul-Po-Mag 22% K_2O also contains 11% Mg	90	180	270	360	450
Wood ash (dry, fine, grey) 5% K_2O, raises pH	400	800	1200	1600	2000
Alfalfa meal 2% K_2O also contains 2.5% N	1000	2000	3000	4000	5000
Greensand or Granite dust 1% K_2O (x 4) [a]	8000	16000	24000	32000	40000
Potassium sulfate 50% K_2O	40	80	120	160	200

[a] Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil-testing lab (Reference 41).

An example of how to determine nutrient needs for potatoes.

An acre of potatoes will be grown on mineral soil. The macronutrient requirement for a potato crop is 150 lb. N, 200 lb. P, and 200 lb K per acre. The soil test shows a pH of 6.0, with high P and medium K levels and recommends 150 lbs N/acre, 100 lbs P_20_5/acre and 100 lbs K_20/acre (see Table 8.2.2). Because the pH is above 5.5, scab resistant varieties will be used. The field has 3% organic matter and a stand of red clover that will be turned in a week or so prior to planting (see Table 3.1). Last summer 4000 gallons/acre of liquid dairy manure was applied and immediately incorporated after a hay harvest. Nutrient credits for soil organic matter, manure, and cover crop appear in Table 8.2.7.

Table 8.2.3 indicates about 56 lbs. of Nitrogen will be released in the first season from the 4000 gallons of liquid dairy manure. Estimate that each percent organic matter will release about 20 lbs. of N, so the 3% soil organic matter will supply 60 lbs. Looking at table 3.1, the red clover will release about half its fixed N, or 50 lbs. as it decomposes, for a total estimated N released and available for plant uptake of 166 lbs. per acre. No additional N is needed. The 40 lbs. of phosphate released from the dairy manure will need to be supplemented with an additional 60 lbs P_2O_5 This could be achieved by applying 400 lbs per acre of bone meal to meet the soil test recommendation of 100 lbs per acre. Potassium will also need to be supplemented in this example. The manure supplies 92 of the 100 lbs. K_2O needed. Broadcasting 16 lbs. of potassium sulfate from an organically approved product can supply the remaining 8 lbs. K_2O/acre.

Table 8.2.7 Example: Calculating Nutrient Credits and Needs Based on Soil Sample Recommendations.

	Nitrogen (N) lbs/acre	**Phosphate (P_2O_5) lbs/acre**	**Potash (K_2O) lbs/acre**
1. Total crop nutrient needs:	150	200	200
2. Recommendations based on soil test	150	100	100
3. Credits			
a. Soil organic matter 3%	60	0	0
b. Manure liquid dairy, 4000 gallons	56	40	92
c. Compost - none	0	0	0
d. Cover crop – red clover	50	0	0
4. Total credits:	166	40	92
5. Additional needed (2-4)	0	60	8

Additional Resources
Using Organic Nutrient Sources (reference 42b)
Determining Nutrient Applications for Organic Vegetables (Reference 42c)

9. MOISTURE MANAGEMENT

Water management and rainfall are among the most important factors determining yield and quality of potatoes. Growth cracks, hollow heart, blackspot, internal necrosis, knobby tubers, seed piece decay, Rhizoctonia and tuber late blight can be related to excessive amounts of water. Before growing potatoes, consider soil type, rainfall distribution and the ability to irrigate. Soil types can vary threefold in their respective water holding capacity. Also, note that potatoes have a relatively shallow root system, with an effective rooting depth of approximately 2 feet. Rainfall in the Northeast can provide adequate water for a crop, but it must be distributed evenly over the growing season to avoid drought stress. During mid-season crop evapotranspiration can easily exceed one inch per week. To prevent drought stress, soils should not be allowed to dry below 65 percent of field capacity. On some soil types rainfall or irrigation would have to occur on a weekly basis to provide the required water for productive crop growth. Rainfall use efficiency can be enhanced by not planting on steep slopes, properly preparing (tillage) soil to improve infiltration, and by placing small soil dams in furrows to reduce surface movement. If irrigation is used, water should be applied to the soil frequently in light amounts to maintain a uniform and adequate water supply. There are several irrigation methods, including center pivot irrigation, solid set sprinklers, wheel line sprinklers, gun and reel units, furrow irrigation and sub-irrigation. Sprinkler irrigation systems frequently provide the most flexibility and the best opportunity for efficient water application. Furrow and sub-irrigation require more uniform soil types and a relatively level field, and are more prone to uneven water application.

10. HARVESTING

10.1 Vine Killing

Potatoes need 2-3 weeks between vine kill and harvest to promote tuber maturity and adequate skin set. Mature skin protects tubers from disease, resists skinning and bruising during harvest and transport, and prolongs tuber storage life.

Optimally, vine killing is accomplished mechanically using a flail mower. A flame weeder might be used several days after mowing to assure complete vine kill. Care should be taken to minimize damage to tubers by mowing equipment or by dislodged rocks that can also injure tubers.

Vines can also be allowed to senesce naturally by reducing water applications in some cultivars. Another option is to allow frost to kill the vines. However, potatoes left to mature in the ground for 2-3 weeks after a frost are susceptible to damage by additional frosts and disease.

Herbicides allowed for certified organic production and labeled for vine kill in potato (e.g. Axxe) have recently come on the market. Research is needed to determine the effects of organically approved vine-kill products on tuber quality.

10.2 Early Maturity and Timely Harvest.

Use of early maturing varieties and scheduling vine killing/harvest as soon as the crop is mature eliminates the food source for the Colorado potato beetle and reduces the number and health of overwintering adults. This practice is also useful in minimizing crop damage by late-season pests, especially aphids and the virus pathogens they transmit. See updated Cornell postharvest storage notes (Reference 45)

10.3 Post Harvest Sanitation

Facilities and handling equipment such as bin pilers should be cleaned and disinfected properly before potatoes are placed in storage. See Table 10.3.1. Structural, mechanical, and electrical problems should be identified and repaired before the storage area is filled. Check for breaks in moisture barriers and insulation to avoid cold spots during the winter. The use of sanitizer wash treatments can prevent the spread of decaying bacteria by killing the organism on contact.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 10.3.1 Rates for Sanitizers for Postharvest Potato Crops and/or Postharvest Facilities

Active ingredient **Product name**	***Uses***			
	Food contact surfaces[1]	**Hard surface, non-food contact[1]**	**Vegetable surface (spray or drench)**	**Vegetable rinse water**
chlorine dioxide				
CDG Solution 3000	50 ppm solution	500 ppm dilution	-	5 ppm solution
Oxine[2]	100 ppm solution	500 ppm solution	-	In tanks, use a 5 ppm solution; for process waters use a chemical feed pump or other injector system at 3 ¼ fl oz per 10 gal water.[3]
Pro Oxine[2]	50-200 ppm solution	500 ppm solution	-	-
hydrogen peroxide/peroxyacetic acid				
Enviroguard Sanitizer	-	2.5-20 fl oz/5 gal water	1 fl oz/20 gal water	1 fl oz/20 gal water
Oxonia Active	1-1.4 oz/4 gal water	1 oz/8 gal water.	-	-
Peraclean 5	1-1.5 fl oz/5 gal water		-	-
Peraclean 15	0.33 fl oz/5 gal water		-	-
Perasan 'A'	1-6.1 oz/6 gal	-	4 oz/20 gal water	4 oz/20 gal water
Per-Ox	1-2.25 fl oz/5 gal water	1-10 fl oz/15 gal water	1 fl oz/5 gal water	1 fl oz/5 gal water
SaniDate 5.0	1.6 fl oz/ 5 gal water	1.6 fl oz/ 5 gal water	59.1 to 209.5 fl oz/ 1,000 gallons water	59.1 to 209.5 fl oz/ 1,000 gallons water
SaniDate 12.0	-	-	25.6 to 89.6 fl oz / 1,000 gallons water	25.6 to 89.6 fl oz / 1,000 gallons water

Table 10.3.1 Rates for Sanitizers for Postharvest Potato Crops and/or Postharvest Facilities				
Active ingredient	**Uses**			
Product name	**Food contact surfaces[1]**	**Hard surface, non-food contact[1]**	**Vegetable surface (spray or drench)**	**Vegetable rinse water**
Shield-Brite PAA 5.0	1.6 fl oz/5 gal water	1.6fl oz/5 gal water	0.5 fl-1.9 fl oz/ gal water. Prior to storage, spray diluted solution on tuber to runoff to achieve full and even coverage. The use of additional surfactant is acceptable to aid in sticking. Use 1 to 2 gal water/ton potatoes.	-
Shield-Brite PAA 12.0	-	-	25.6 to 107 fl.oz/1,000 gal water	25.6 to 107 fl.oz/1,000 gal water
StorOx 2.0	0.5 fl oz/gal water	0.5 fl oz/1 gal water	1.25-2.5 fl. oz./ gal water. Prior to storage, spray diluted solution on tuber to runoff to achieve full and even coverage. The use of additional surfactant is acceptable to aid in sticking. Use 1 to 2 gals water/ton potatoes.	-
Tsunami 100	-	-	2.5-6.7 fl oz/100 gal water	2.5-6.7 fl oz/100 gal water
Victory	-	-	1 fl oz/16.4 gal water	1 fl oz/16.4 gal water
VigorOx 15 F & V	0.31-0.45 fl oz/5 gal water	1.1-9.5 fl oz/5 gal water	1 fl oz/ 16 gal water as spray or dip	0.54 fl oz/ 16 gal water
VigorOx LS-15	0.31-0.45 fl oz/5 gal water	1.1-9.5 fl oz/5 gal water	-	-
sodium hypochlorite				
San-I-King No. 451	100 ppm chlorine in solution	-	-	-

1. Thoroughly clean all surfaces and rinse with potable water prior to treatment. 2. Requires acid activator. 3. After treatment, rinse with potable water.

10.4 Curing and Storage

Cuts and bruises heal most rapidly under conditions described previously for precutting seed (see 7.2: *Seed preparation and handling*). High relative humidity at 50° to 60°F should be provided for two to three weeks at the beginning of the storage period. After this, the temperature should be gradually lowered to 40°F for tablestock or seed potatoes, or maintained at 50°F for chipstock varieties such as Atlantic and at 45°F for Andover, Marcy, Reba or Snowden. When a condition such as field frost, late blight, or ring rot that favors decay is present, the curing period should be eliminated and the temperature dropped as soon as possible.

Desired storage temperature is best achieved with forced-air ventilation controlled thermostatically by an air proportioning system. Airflow should be uniform throughout the storage facility to maintain consistent temperature and oxygen levels. Airflow rates early in the storage season may range from a continuous flow of 1/2 to 1 cu. ft./cwt/min. with high relative humidity to enhance the curing process. Later a maintenance program should use an airflow of 1/2 to 4/5 cu. ft./cwt/min. as needed (five to ten percent of the time, or 1.2-2.5 hr/day). If severe rot potential exists, continuous airflow rates as high as two cu. ft./cwt/min. may be required to cool and dry the tubers. Excessive airflow rates, particularly at low relative humidity, will dehydrate tubers and interfere with the wound healing process. Relative humidity in storage should be as high as possible without causing condensation on the tubers and the storage structure. Good insulation properly protected with a vapor barrier reduces the danger of condensation.

10.5 Sprout Suppressors

Products available for sprout control in organic production are best described as sprout suppressors. Sprout suppressors, used in conjunction with good storage management may help extend the storage season. Although most potato varieties are dormant for two to three months after harvest, they will eventually sprout even in low temperature cold storage. Unlike chlorpropham (CIPC), the sprout inhibitor used by conventional growers, organically approved sprout management products require repeated applications. Sprout suppressors are most effective when applied before sprouts are one-eighth of an inch long. Application methods will depend on storage management and cultivars grown. See Table 10.5.1 and article, Organic and

Alternative Methods for Potato Sprout Control in Storage (Reference 43). It is important to examine tubers in the center and at the base of the pile at frequent intervals during the storage season to make sure that storage rots, internal sprouting, or other disorders are not developing. Seed potatoes should not be treated or stored where sprout inhibitor vapors may reach them.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 10.5.1 Sprout Suppressors (See Reference 43 for more information on these products).

Class of Compounds Product Name (*active ingredient*)	**Rate/A Product**	**PHI (days)**	**REI (hours)**	**Efficacy**	**Comments**
Volatile Oils					
Certified organic peppermint oil[1]	10 lbs oil/1000cwt potatoes/ month	-	-	1	25(b) pesticide. Effective in 1/1 trial. Wick application method most effective; apply 50 ppm every two weeks, 75 ppm every three weeks, or a daily application of 4 ppm.
Certified organic clove oil[1]	5.2 lbs/1000 cwt	-	-	1	25(b) pesticide. Effective in 1/1 trial. Apply as thermal aerosol; repeat applications of 1.9 lbs/1000cwt necessary at 2-3 week intervals.
Decco 070 EC Potato Sprout Inhibitor*(clove oil)*	1 gal/69 gal water	-	-	1	25(b) pesticide. Effective in 1/1 trial. Apply on washed and damp dried potatoes using spray nozzles placed evenly across the rollers on which the potatoes are being moved.
Decco Aerosol 100 For Treatment of Potato in Storage*(clove oil)*	1 gal/2000-3000 cwt potatoes	-	-	1	25(b) pesticide. Effective in 1/1 trial. Designed for use through Forced Air Distribution System. Usually performed by lisenced applicators.

1 Check with your certifier before use. If potatoes are sold as a food crop, Reference 44 (Section 205.606 National Organic Standards) applies; since non-organically produced clove and peppermint oils are not on this approved products list, certified organic clove and peppermint oils are required. If potatoes are sold as seed potatoes, certified organic oil is not required. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available

11. USING ORGANIC PESTICIDES

Given the high cost of many pesticides, and the limited amount of efficacy data from replicated trials with organic products, the importance of developing an effective system of cultural practices for insect and disease management cannot be emphasized strongly enough. **Pesticides should not be relied on as a primary method of pest control**. Scouting and forecasting are important for detecting symptoms of diseases at an early stage. When conditions do warrant an application, proper choice of materials, proper timing, and excellent spray coverage are essential.

11.1 Sprayer Calibration and Application

Calibrating sprayers is especially critical when using organic pesticides since their effectiveness is sometimes limited. For this reason, they tend to require the best spraying conditions to be effective. Read the label carefully to be familiar with the unique requirements of some products, especially those with live biological organisms as their active ingredient (e.g. Contans). The active ingredients of some biological pesticides (e.g. Serenade) are actually metabolic byproducts of the organism. Calculating nozzle discharge and travel speed are two key components required for applying an accurate pesticide dose per acre. Applying too much pesticide is illegal, can be unsafe and is costly whereas applying too little can fail to control pests or lead to pesticide resistance.

Resources

Cornell Crop and Pest Management Guidelines Chap. 6 (Ref. 46).
Calibrating Backpack Sprayers (Reference 47)
Pesticide Environmental Stewardship: Calibration (Reference 48)
Knapsack Sprayers – General Guidelines for Use (Reference 49)
Herbicide Application Using a Knapsack Sprayer (Reference 50) (This publication is also relevant for non-herbicide applications.)
Pesticide Environmental Stewardship, Coop Extension (Reference 53a)
Pesticide Environmental Stewardship, CIPM website(Reference 53b)
Vegetable Spraying (Reference 53c)

11.2 Regulatory Considerations

Organic production focuses on cultural, biological, and mechanical techniques to manage pests on the farm, but in some cases pesticides, which include repellents, allowed for organic production are needed. Pesticides mentioned in this organic production guide are registered by the United States Environmental Protection Agency (EPA) or meet the EPA requirements for a "minimum risk" pesticide. At the time of publication, the pesticides mentioned in this guide meet New York State Department of Environmental Conservation (NYS

DEC) registration requirements for use in New York State. See Cornell's [Product, Ingredient, and Manufacturer System](#) website (reference 3) for pesticides currently registered for use in NYS. Additional products may be available for use in other states.

To maintain organic certification, products applied must also comply with the National Organic Program (NOP) regulations as set forth in 7 CFR Part 205, sections 600-606 (Reference 52). The Organic Materials Review Institute (OMRI) (Reference 8) is one organization that reviews products for compliance with the NOP regulations and publishes lists of compliant products, but other entities also make product assessments. Organic growers are not required to use only OMRI listed materials, but the list is a good starting point when searching for allowed pesticides.

Finally, farms grossing more than $5,000 per year and labeling products as organic must be certified by a NOP accredited certifier who must approve any material applied for pest management. ALWAYS check with the certifier before applying any pest control products. Some certifiers will review products for NOP compliance.

Note that "home remedies" may not be used. Home remedies are products that may have properties that reduce the impact of pests. Examples of home remedies include the use of beer as bait to reduce slug damage in strawberries or dish detergent to reduce aphids on plants. These materials are not regulated as pesticides, are not exempt from registration, and are therefore not legal to use.

Do you need to be a certified pesticide applicator? The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) defines two categories of pesticides: general-use and-restricted use. NYS DEC also defines additional restricted-use pesticides. Pesticide applicator certification is required to purchase and use restricted-use pesticides. Restricted-use pesticides mentioned in this guide are marked with an asterisk (*). Farmers who purchase and use only general-use pesticides on property they own or rent do not need to be certified pesticide applicators. However, we do encourage anyone who applies pesticides to become certified.

Worker Protection Standard training. If the farm has employees who will be working in fields treated with a pesticide, they must be trained as workers or handlers as required by the federal Worker Protection Standard (WPS). Having a pesticide applicator certification is one of the qualifications needed to be a WPS trainer. Certified pesticide applicators meet the WPS training requirements. For more information on the Worker Protection Standard see: How To Comply with the Worker Protection Standard (Reference 14a). See Revisions To the Worker Protection Standard for a summary of new worker protection standards that will take effect January 2017 (Link 14d). Find more information on pesticide applicator certification from the list of State Pesticide Regulatory Agencies (Reference 14b) or, in New York State, see the Cornell Pesticide Management Education Program website at http://psep.cce.cornell.edu (Reference 14c).

11.3 Pollinator Protection

Honey bees, wild bees, and other insects are important for proper pollination of many crops. Poor pollination results in small or odd-shaped fruit as well as low yields.

To avoid harming bees with insecticides, remember these general points:

- Always read the label before use.
- Do not spray blooming crops;
- Mow blooming weeds before treatment or spray when the blossoms are closed;
- Avoid application during the time of day when bees are most numerous; and
- Make application in the early morning or evening.

If pesticides that are highly toxic to bees are used in strict accordance with label directions, little or no harm should be done to bees. Label statements on pesticides that are highly toxic to honey bees may carry a caution statement such as: "This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area."

In early 2015 the EPA proposed new pollinator protection label language to protect managed bees under contract pollination services. The intent of this new language is to protect bees from contact exposure to pesticides that are acutely toxic to bees. Once the new language is finalized, pesticide labels will include the new wording and requirements. As part of this proposal, EPA identified certain active ingredients that are acutely toxic to bees. Active ingredients mentioned in this publication meeting this criteria are noted with a bee symbol ().

For more information on pollinator protection, visit www.epa.gov/opp00001/ecosystem/pollinator/index.html and pesticidestewardship.org/PollinatorProtection/Pages/ default.aspx

11.4 Optimizing Pesticide Effectiveness

Information on the effectiveness of a particular pesticide against a given pest can sometimes be difficult to find. Some university researchers include pesticides approved for organic production in their trials; some manufacturers provide trial results on their web sites; some farmers have conducted trials on their own. Efficacy ratings for pesticides listed in this guide were summarized from university trials and are only provided for some products. Listing a pest on the pesticide label does not guarantee the effectiveness of a pesticide. The Resource Guide for Organic Insect and Disease Management (Reference 2) provides more comprehensive efficacy information for many approved materials.

In general, pesticides allowed for organic production may kill a smaller percentage of the pest population, could have a shorter residual, and may be quickly broken down in the environment. Microbial-based products often have a shorter shelf life than other products, so be sure to use them by the expiration date. Read the pesticide label carefully to determine if water pH or hardness will negatively impact the pesticide's effectiveness. Use of a surfactant may improve organic pesticide performance. OMRI lists adjuvants on their website (Reference 9). Regular scouting and accurate pest identification are essential for effective pest management. Thresholds used for conventional production may not be useful for organic systems because of the typically lower percent mortality and shorter residual of pesticides allowed for organic production. When pesticides are needed, it is important to target the most vulnerable stages of the pest. The use of pheromone traps or other monitoring or prediction techniques can provide an early warning for pest problems, and help effectively focus scouting efforts. When using pesticides, be sure you have sufficient coverage to provide adequate control. Consult the pesticide label for guidance.

12. Disease Management

In organic systems, cultural practices form the basis of a disease management program. Promote plant health by maintaining a biologically active, well-structured, adequately drained and aerated soil that supplies the requisite amount and balance of nutrients. Choose varieties resistant to one or more important diseases whenever possible (see Table 6.1.2). Plant only clean, disease-free seed and maintain the best growing conditions possible.

Rotation is an important management practice for pathogens that overwinter in soil or in crop debris. Rotating between crop families is useful for many diseases, but may not be effective for pathogens with a wide host range, such as Sclerotinia white mold, Rhizoctonia black scurf, Colletotrichum black dot, Verticillium wilt, common scab, or nematodes. Rotation with a grain crop, preferably a crop or crops that will be in place for one or more seasons, deprives many disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. The same practices are effective for preventing the buildup of root damaging nematodes in the soil, but keep in mind that certain grain crops are also hosts for some nematode species. See more information on crop rotation in Section 4.2.

Other important cultural practices can be found under each individual disease listed below. Maximizing air movement and leaf drying is a common theme. Many plant diseases are favored by long periods of leaf wetness. Any practice that promotes faster leaf drying, such as orienting rows with the prevailing wind, or using a wider row or plant spacing, can slow disease development. Fields surrounded by trees or brush, that tend to hold moisture after rain or dew, should be avoided if possible, especially for a crop like potatoes, with a long list of potential disease problems.

Insect damage can create susceptibility to disease. Feeding by the European corn borer (ECB) can create an avenue for disease infection by *Erwinia spp.*, the pathogen that causes black leg and bacterial soft rot. Survival and establishment of ECB larvae vary depending on potato cultivar and field conditions. Larval survival on three popular cultivars, from highest to lowest, follows: Monona > Superior > Katahdin. Under field conditions, Monona is more susceptible to attack by ECB's and to infection by aerial blackleg than other cultivars.

Scouting fields weekly is key to early detection and evaluation of control measures. The earlier a disease is detected, the more likely it can be suppressed with organic fungicides. Accurate identification of disease problems, especially recognizing whether they are caused by a bacterium or fungus, is essential for choosing an effective control strategy. Anticipate which diseases are likely to be problems and be ready to take control action in a timely manner. Allowing pest populations to build past thresholds can leave few or no options for control. Thresholds presented here were developed for use with conventional fungicides, and may need to be adjusted downward when using materials approved for organic production, which tend to be less effective and have shorter residual activity.

When available, scouting protocols can be found in the sections for each individual disease. While following a systematic scouting plan, keep watch for other disease problems when walking a field.

All currently available fungicides allowed for organic production are protectants meaning they must be present on the plant surface before disease inoculum arrives to effectively prevent infection. Biological products must be handled carefully to keep the microbes alive. In addition to disease control, fungicides containing copper may have antifeedant activity against some insect pests including the Colorado potato beetle. Follow label instructions carefully to achieve the best results.

Use weather-based disease forecasting programs when available to help time applications to periods of favorable weather or the arrival of inoculum. The movement of some pathogens that do not overwinter in the Northeast may be tracked online to help determine when control measures are needed. Contact New York State IPM's network for the environment and weather (Reference 4) for late blight forecasting in your area.

Contact your local cooperative extension office to see if newsletters and pest management updates are available for your region, for example, in western New York, the Cornell Vegetable Program offers subscriptions to *VegEdge* a report that gives timely information regarding crop development, pest activity and control. Enrollment in the Eastern New York Commercial Horticulture Program includes a subscription to *Produce Pages* and weekly seasonal newsletters for vegetables, tree fruit, grapes and small fruit. On Long Island, see the *Long Island Fruit and Vegetable Update.*

Organic farms must comply with all other regulations regarding pesticide applications. See Section 11: *Using Organic Pesticides* for details. **ALWAYS check with your organic farm certifier when planning pesticide applications**.

Resources:

Cornell Vegetable MD Online (Reference 57).

Resource Guide for Organic Insect and Disease Management (Ref 2).

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.1.1 Pesticides for Organic Potato Disease Management

CLASS OF COMPOUNDS **Product Name (*active ingredient*)**	**BACTERIAL SOFT ROT,**	**FUSARIUM DRY ROT**	**EARLY BLGHT**	**LATE BLIGHT**	**BLACK DOT ROOT ROT**	**CANKER AND BLACK SCURF**	**BOTRYTIS VINE ROT**	**WHITE MOLD**	**COMMON SCAB**	**PINK ROT**	**POWDERY SCAB**	**PYTHIUM LEAK**	**SILVER SCURF**	**VIRUSES**
MICROBIAL														
Actinovate AG *(Streptomyces lydicus)*	c	b, c	c			a, b	b, c	b, c		a, b, c		a, b, c		
Actinovate STP *(Streptomyces lydicus)*		a				a		a		a		a		
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)		b				b		b		b		b		
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)		b				b		b		b		b		
Contans WG *(Coniothyrium minitans)*								b						
Double Nickel 55 *(Bacillus amyloliquefaciens str. D747)*	c	b	c	c		b	c	c		b		b		
Double Nickel LC *(Bacillus amyloliquefaciens str. D747)*	c	b	c	c		b	c	c		b		b		
MycoStop Biofungicide *(Streptomyces griseoviridis)*		b	b											
MycoStop Mix *(Streptomyces griseoviridis)*		b	b											
Optiva *(Bacillus subtilis str. QST 713)*			c	c			c	c						
Prestop Biofungicide (*Gliocladium catenulatum Str. J1446*)		b				b	c			b		b	a	
Regalia Biofungicide (*Reynoutria sachalinensis*)		b	c	c		b	c	c	b	b		b		
RootShield Granules *(Trichoderma harzianum Rifai strain T-22)*		b				b						b		
RootShield PLUS+ WP *(Trichoderma harzianum str. T-22, Trichoderma virens str. G-41)*		a,b		a		a,b				a,b		a,b		
Rootshield WP (*Trichoderma harzianum st T-22*)		a, b				a, b						a, b		
Serenade ASO (*Bacillus subtilis* str *QST 713*)			c	c			c	c						
Serenade MAX (*Bacillus subtilis* str *QST 713*)			c	c			c	c						
Serenade Opti (*Bacillus subtilis* str QST 713)							c	c						
Serenade Soil (*Bacillus subtilis* str QST 713*)*	b	b				b				b		b		
Serifel (*Bacillus amyloliquefaciens*)			c	c	c		c	c						
SoilGard (*Gliocladium virens str. GL-21*)						b						b		
Taegro Biofungicide (*Bacillus subtilis var. amyloliquefaciens str.n FZB24*)		a, b				a, b								
Zonix *(Rhamnolipid Biosurfactant)*				c						b		b		

Table 12.1.1 Pesticides for Organic Potato Disease Management

CLASS OF COMPOUNDS **Product Name (*active ingredient*)**	**BACTERIAL SOFT ROT,**	**FUSARIUM DRY ROT**	**EARLY BLGHT**	**LATE BLIGHT**	**BLACK DOT ROOT ROT**	**CANKER AND BLACK SCURF**	**BOTRYTIS VINE ROT**	**WHITE MOLD**	**COMMON SCAB**	**PINK ROT**	**POWDERY SCAB**	**PYTHIUM LEAK**	**SILVER SCURF**	**VIRUSES**
COPPER														
Badge X2 *(copper oxychloride, copper hydroxide)*			c	c										
Basic Copper 53 *(copper sulfate)*			c	c										
Champ WG *(copper hydroxide)*			c	c										
***Copper Sulfate Crystals** *(copper sulfate pentahydrate)*				c										
CS 2005 *(copper sulfate pentahydrate)*			c	c										
Cueva Fungicide Concentrate *(copper octanoate)*			c	c										
Nordox 75 WG (*cuprous oxide)*			b	c										
Nu-Cop 50DF *(copper hydroxide)*			c	c										
Nu-Cop 50 WP (*cupric hydroxide*)			c	c										
Nu-Cop HB *(cupric hydroxide)*			c	c										
***Quimag Quimicos Aguila Copper Sulfate Crystal** *(copper sulfate)*				c										
OIL														
Organic JMS Stylet Oil *(paraffinic oil)*														c
Pure clove oil *(clove oil[1])*													d	
PureSpray Green *(petroleum oil)*														c
Trilogy *(hydrophobic extract of neem oil)*			c				c	c	c		c			
OTHER														
Agricure (*potassium bicarbonate*)							c							
GreenCure (*potassium bicarbonate*)							c							
Milstop (*potassium bicarbonate*)							c							
PERpose Plus (*hydrogen peroxide/dioxide*)	c	c	c	c		c	c	c	c	c	c	c		
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*			c	c		a,b,c								
TerraClean 5.0 *(hydrogen dioxide, peroxyacetic acid)*	b	b				b				b		b		

* Restricted use pesticide. Restricted-use pesticides can be purchased only by certified applicators and used by certified applicators or by those under the direct supervision of a certified applicator. a = seed treatment, b = in furrow/ soil drench, c = foliar treatment, d= post harvest treatment, e = fixed copper fungicides include basic/tribasic copper sulfate, copper oxychloride sulfate, as well as copper hydroxide. Copper will build up in the soil, depending on a variety of factors. In general, copper hydroxides are less toxic than copper sulfates. See copper products fact sheet in the Resource Guide for Organic Insect and Disease Management (Reference 2) for more information about using copper.

1. For post harvest control of silver scurf on a food potato crop, clove oil must be certified organic. For post harvest silver scurf control for seed potato crop, clove oil must be 100% pure, but not necessarily certified organic. (Reference 44) See 12.16: Silver scurf. a, b, c or d = can be used for pest in New York and OMRI listed

Active ingredient meets EPA criteria for acute toxicity to bees

12.1 Bacterial Soft Rot, *Erwinia spp*.

Time for concern: At planting, and between harvesting and marketing. Wet, anaerobic soils favor the disease.

Key characteristics: This bacterial pathogen can cause soft rot of infected tubers, resulting in seed piece decay and reduced yield and quality at harvest. Erwinia infection can also produce symptoms known as 'black leg': stunted, yellow stems that become black and rotted at ground level. Tubers are infected through wounds or lenticels, and develop tan or water-soaked areas on the tuber surface. Advanced infections will be seen as soft rot of the tuber flesh. The amount of damage depends on the population of the bacteria on and in the seed, seed storage and handling practices, and variety susceptibility. See Cornell fact sheet (Reference 55) and Ohio State fact sheet (Reference 56) for photos and more information.

Injury to potato plants by the European corn borer can cause sites for above and below ground *Erwinia* infection.

Relative risk: Reduce risk to this wound pathogen by avoiding injuries and providing conditions favorable to wound healing at planting and harvest. See Sections 7.2: *Seed preparation and handling*, 7.3: *Planting* and 10.4: *Curing and storage*.

Management Option	Recommendation for Bacterial Soft Rot
Scouting/thresholds, Crop rotation	These are not currently viable management options.
Site selection	Choose well-drained soils; wet, anaerobic conditions favor disease development. Infection of the lenticels is common in saturated soils.
Resistant varieties	No resistant varieties are available. Plant varieties less susceptible to European corn borer.
Seed selection/treatment	The primary source of inoculum is infected seedpieces. Plant only phytosanitary certified seed (See Section 7.1: *Seed source*s). Some growers have reduced seed piece decay by applying untreated fir bark to suberized seed pieces.
Planting	The bacteria can spread to healthy seedpieces during cutting and planting. Clean and sanitize cutting equipment before use, during the cutting process and between seed lots.
Harvest	Avoid injuries to tubers during harvest and avoid harvesting when soil temperatures are higher than 70°.
Postharvest	Provide good conditions for wound healing (55° to 60°F and 95 percent relative humidity, with good ventilation) for two to three weeks. Following the curing period, temperatures should be kept as low as possible.
Storage	Severely affected tuber lots should not be stored. Do not move potatoes unnecessarily during the storage period because new wounds will be created. Soft rot bacteria can also act as secondary pathogens in tubers infected with other diseases.
Notes	Tubers grown with excessive amounts of nitrogen are very susceptible to soft rot.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.1 Pesticides for Management of Bacterial Soft Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	3-12 oz/acre	up to day	1 or until dry	?	Label recommends using a spreader sticker for foliar applications.

Table 12.1 Pesticides for Management of Bacterial Soft Rot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre	0	4	?	
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Serenade Soil[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre Soil treatment	0	4	?	Soil drench or in-furrow.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water soil treatment	up to day	0	?	Apply at 25-100 gallons of solution per acre row. Soil treatment prior to seeding/ transplanting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl.oz./ 200 gal water/1000 sq ft of soil soil treatment	up to day	0	?	Soil treatment with established plants.

PHI = pre-harvest interval, REI = restrictedentry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available . [1]Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2] Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest

12.2 Fusarium Dry Rot Seed piece decay primarily *Fusarium sambucinum*, but also *F. coeruleum and F. graminearum*

Time for concern: During planting, harvest, and postharvest, if soil is cold and pathogen is present.

Key characteristics: Fusarium spp. fungi cause dry rot in stored tubers and seed piece decay. Symptoms include sunken and shriveled areas on the surface of the tubers. The rot may extend to the center of the tuber and contain a fungal growth that is pink, white, or yellow. Soft rot bacteria can colonize dry rot lesions, making diagnosis difficult. The fungus originates in contaminated seed or infested soil. See Cornell general fact sheet (Reference 55) and dry rot fact sheet (Reference 58) for photos and more information.

Relative risk: Dry rot occurs annually and is perhaps the most important cause of post harvest potato losses in the northeastern United States.

Management Option	Recommendation for Fusarium Dry Rot
Scouting/thresholds	Inspect seed for Fusarium dry rot before purchasing. If necessary, grade out affected tubers before cutting seed.
Site selection	To reduce disease spread, plant seed in warm ground and cover with as little soil as practical. Avoid fields with a history of Fusarium dry rot.
Resistant varieties	No resistant varieties are available.
Seed selection/treatment	Seed quality is the most important factor in minimizing losses due to this disease. Plant only phytosanitary certified seed. Carefully inspect seed at the time of receipt. If possible, evaluate the seed

Management Option	Recommendation for Fusarium Dry Rot
	before it is shipped. Warm seed to at least 50°F before handling and cutting to minimize injury and promote growth. Bruising the seed during handling spreads the disease. Protect seed from wind and sunlight during planting because dehydration weakens seed. Cut only as much seed as can be planted in 24 hours. Cut with sharp knives and disinfect seed cutting and handling equipment often. Always disinfect between seed lots. Do not mix seed lots.
Planting	Shallow planting and light cultivation to break up compact soil will increase soil temperature, improve oxygen levels aroung the seed piece, and speed plant growth.
Crop rotation/Sanitation	These are not currently viable management options.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.2 Pesticides for Management of Fusarium Dry Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	1-12 oz/acre soil treatment 3-12 oz/acre soil treatment 2-18 cwt of seed seed treatment	Up to day	1 or until dry	?	Soil treatment at planting Soil treatment in season. Reapply every 7-14 days.
Actinovate STP (*Streptomyces lydicus*)	4-32 cwt of seed seed treatment	-	1 or until dry	?	
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band 2.5-5 lb/acre broadcast	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
MycoStop (*Streptomyces grieoviridis* str K61)	15-30 oz/acre soil treatment	-	4	?	Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop into the root zone.
MycoStop Mix (*Streptomyces grieoviridis* str K61)	7.6-30 oz/acre soil treatment 0.5-1 treated acre soil treatment	-	4	?	Use at planting; no pre-harvest interval noted. Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop into the root zone. Lightly incorporate furrow or band applications. Band, in-furrow or side dress.

Table 12.2 Pesticides for Management of Fusarium Dry Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil drench	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.
Regalia (*Reynoutria sachalinensis*)	1-3 qt/100 gal water soil drench 1-4 qt/acre in-furrow treatment	0	4	?	
RootShield Granules (*Trichoderma harzianum*)	2.5-6 half acre in-furrow treatment	-	0	?	
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.25-1.5 lb/ 20 gal water seed treatment seed piece dip 0.03-3 lb/ cwt seed seed piece dust 16-32 oz/acre in-furrow treatment	0	4	1	*Trichoderma harzianum* products effective in 1/1 trial. Seed piece dip. Do not apply when above-ground harvestable food commodities are present.
RootShield WP (*Trichoderma harzianum*)	0.03-3 oz/ cwt seed seed treatment 16-32 oz/acre in-furrow treatment	-	until dry	?	For use in planter box only.
Serenade Soil[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre soil treatment	0	4	?	Soil drench or in-furrow.
Taegro (*Bacillus subtilis*)	3 tsp/gal water seed piece treatment 2.6 oz/100 gal water in-furrow treatment	-	24	?	Dip tubers for 10 to 30 minutes before planting. Soil drench or over furrow at time of planting. For best results, make two or three applications spaced one week apart.

Table 12.2 Pesticides for Management of Fusarium Dry Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment Apply at 25-100 gallons of solution per acre row. 25 fl oz/ 200 gal water/1000 sq ft of soil soil treatment	up to day	0	?	Soil treatment prior to seeding/ transplanting. Soil treatment with established plants.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1]Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest

12.3 Early Blight, primarily *Alternaria solani*

Time for concern: Early to mid-July through harvest in warm and humid weather.

Key characteristics: This fungus causes leaf lesions that are dark brown and appear leathery with faint, concentric rings giving a "target-spot" effect. Spots grow to 1/2 inch. Under prolonged warm and humid conditions, spots may enlarge or coalesce, causing leaf yellowing and early senescence. Severe defoliation will reduce yields. Tuber infections appear as small, irregular, brownish black spots that are usually sunken. The rotted tuber tissue is firm, hard, and somewhat corky. Tuber infection is much less common than foliar infection. Early blight overwinters in infected plant debris and potato tubers. See Cornell general fact sheet (Reference 55), early blight fact sheet (Reference 59) and Michigan State photos (Reference 60).

Relative Risk: Prevalent in most growing seasons, but in comparison with late blight, this disease is less serious. There is a high risk for significant defoliation and yield reduction when susceptible varieties are grown in a warm, wet year.

Management Option	Recommendation for Early Blight
Scouting/thresholds	Record the occurrence and severity of early blight. Use NEWA the potato disease forecast to help time fungicide applications where early blight is a recurring problem and work to extend your rotation.
Site selection	Select well-drained fields. Avoid planting adjacent to other solanaceous hosts such as tomato and eggplant, or adjacent to fields that were infected with early blight in the previous season, since these fields may serve as inoculum sources.
Planting	Plant rows in an east-west direction and used wide row spacing, 36 inches, to reduce prolonged leaf wetness.
Crop rotation	Minimum two-year rotation without potatoes, tomatoes, or eggplants if severe outbreaks have occurred.
Resistant varieties	Potato varieties differ in their susceptibility to early blight. Late maturing varieties are usually more resistant to early blight. See Section 6: *Varieties*.
Seed selection/treatment	Plant phytosanitary certified seed. See Section 7.1: *Seed sources*.
Irrigation	Drip irrigation or very early morning overhead irrigation, which will allow the leaves to be dry for long periods, is preferred.
Vine killing	Allowing tubers to mature in the ground for at least two weeks after the vines die can reduce infection to tubers. Dig when the vines are dry.
Harvest	Avoid wounding tubers during harvest and post harvest operations.

Management Option	Recommendation for Early Blight
Sanitation	Plow under all plant debris and volunteer potatoes immediately after harvest.
Storage	Examine tubers and discard infected tubers before storage. Periodically check stored tubers for disease symptoms.
Notes	Environmental stresses such as drought and nitrogen and phosphorous deficiencies increase susceptibility to early blight.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.3 Pesticides for Management of Early Blight

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	3-12 oz/acre	up to day	1 or until dry	3	Reapply every 7-14 days. Streptomyces lydicus products effective in 0/1 trial.Use a spreader sticker.
Badge X2 (copper hydroxide, copper oxychloride)	1-4 lb/acre	0	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Basic Copper 53 (basic copper sulfate)	3-4.7 lb/acre	up to day	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Champ WG (copper hydroxide)	1-4 lb/acre	-	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil. For Champ WG apply 1-1.5 lbs/A where disease is light and up to 3 to 4 lbs/A where disease is more severe. Application of Champ WG at rates and timing recommended for control of Early and Late Blight may provide suppression of Colorado Potato Beetle.
CS 2005 (copper sulfate pentahydrate)	19.2-32 oz/acre	0	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Cueva (copper octanoate)	0.5-2 gal/acre	up to day	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	Suppression only.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre	0	4	?	Suppression only.
Nordox 75 WG (cuprous oxide)	0.66-4 lb/acre	-	12	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil. Apply Nordox 75 WG every 7-10 days when plants are 6 inches high until harvest.

Table 12.3 Pesticides for Management of Early Blight					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Nu-Cop 50 WP (copper hydroxide)	1-1.5 lb/acre (light infestation) ; 3-4 lb/acre (heavy infestation)	1	24	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil. Apply every 7-10 days when plants are 6 inches high.
Nu-Cop 50DF (copper hydroxide)	1-4 lb/acre	1	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Nu-Cop HB (copper hydroxide)	0.5-2 lb/acre	-	48	2	Copper based products effective in 1/2 trials. In warm, wet weather, significant defoliation will occur. Copper can build up in the soil.
Optiva (*Bacillus subtilis* str QST 713)	14-24 oz/acre	0	4	?	Suppression only.Repeat on a 5-7 day interval or as needed.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water Curative	0	until dry	?	Apply at first sign of disease. Spray consecutive applications until control is achieved and then follow directions for preventative treatment. Bee Hazard. This product is toxic to bees exposed to direct contact.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl.oz./100 gal water Preventative	0	until dry	?	Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce rate to 32 fl oz/100 gal preventative rate after completion of third treatment and maintain 5-day interval spray cycle until harvest. Bee Hazard. This product is toxic to bees exposed to direct contact.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre	0	4	?	Repeat on a 5-7 day interval or as needed.
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	Repeat on a 5-7 day interval or as needed.For suppression, begin applications of Serenade ASO or Serenade MAX soon after emergence and when conditions are conducive to disease development.

Table 12.3 Pesticides for Management of Early Blight					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	Repeat on a 5-7 day interval or as needed.For suppression, begin applications of Serenade ASO or Serenade MAX soon after emergence and when conditions are conducive to disease development.
Serifel (*Bacillus amyloliquefaciens*)	4-16 oz/acre	0	4	?	
Trilogy (neem oil)	0.5-1% solution in 25-100 gal of water/acre	Up to day of harvest	4	?	Maximum labeled rate of 2 gallons/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restrictedentry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

12.4 Late Blight, *Phytophthora infestans*

Time for concern: Throughout the growing season and in storage. High moisture and moderate temperatures (60-80°F) favor late blight development; disease will stall in hot weather.

Key characteristics: This fungus causes lesions on leaves and stems that appear as small flecks within three to five days after infection. The infected tissue is initially water-soaked but becomes brown or black in a few days. Lesions are often surrounded by a halo of light green tissue. Under high humidity, sporulation is visible as a delicate, white mold surrounding the lesion. Rain may wash spores down the stems and infect tubers. Infected tubers develop a shallow reddish-brown corky dry rot. Bacterial soft rot often follows. Late blight overwinters on infected, stored tubers or tubers left in the field. See Cornell fact sheet (Reference 61), disease cycle (Reference 62), control options (Reference 63),and organic management options (Reference 63 B).

Relative Risk: This disease is occurring with increasing regularity and can be totally devastating when present. In very wet cool weather, infections can spread quickly, leading to 50% or greater reductions in yield even with copper sprays, and complete yield loss if no control measures are taken. Hot weather slows disease progress.

Management Option	Recommendation for Late Blight
Scouting/thresholds	Scout fields weekly for late blight symptoms. A forecasting system for late blight is available for some New York locations through the Network for Environment and Weather Awareness Potato disease forecast (Reference 4). Late blight is first expected to appear 1-2 weeks after 18 Blitecast Severity Values (SV) have accumulated, starting with the emergence of green tissue from the source of late blight inoculum. The source of inoculum could be plants growing from infected tubers in a cull pile, volunteers growing from infected tubers that survived the winter, or infected seed tubers. For a more comprehensive disease management system, sign up for an account on the Late Blight Decision Support System. Start scouting soon after 18 SV have accumulated if a late blight forecast is available for your area, or when potatoes are 4-6" high. Conventional farmers begin applying fungicides at this point and maintain coverage until harvest, adjusting spray intervals to reflect weather conditions as described below. If late blight is found early in the season and weather is very favorable it may not be possible to control it adequately using approved copper products, and the field may need to be disked under.

Management Option	Recommendation for Late Blight
	Track where late blight has been found in NY and monitor potential sources of late blight spores from off your farm at usablight.org (Reference 64). If late blight is found in your county or adjacent counties, apply an approved copper fungicide immediately even if late blight has not been found in your field. The fungicide must be present before infection occurs to have a chance of successful control. Coverage should be excellent throughout the canopy. Once fungicide applications have started, use the potato disease forecast help determine spray intervals. Be aware that copper can build up in the soil. See Resource Guide for Organic Insect and Disease Management (Reference 2) and organic management options (Reference 63B) for more information about using copper fungicides. If present, harvest the crop early before it becomes contaminated. Harvest new potatoes and sell early, if possible.
Site selection	Avoid fields that cannot be effectively sprayed. Fields surrounded by trees that shade and slow air movement, or those remaining damp late into the morning are at higher risk for infection.
Crop rotation	Do not plant potatoes near a field where late blight occurred the previous year and there is a potential for volunteer plants growing from unharvested tubers.
Resistant varieties	Potato varieties differ slightly in their susceptibility, but commercial varieties do not have useful levels of resistance. Late variety Elba has foliar resistance but not tuber resistance. Choose early maturing varieties that will allow early harvest.
Seed selection/treatment	Infected seed potatoes serve as an important source of inoculum. Plant phytosanitary certified seed (See Section 7.1: Seed sources). Know your seed grower. Even state phytosanitary certified seed may have a low percentage of late blight. Obtain plant health certification from state certifying agency indicating if late blight was present in the field. Phytosanitary certified seed must have no more than 1% late blight tuber rot.
Planting	Plant on proper row spacing to ensure adequate air flow around leaves and leaf drying.
Hilling	Proper hilling practices reduce the exposure of tubers to spores.
Vine killing	Proper vine-killing practices reduce the exposure of tubers to spores. See Section 10.1: Vine killing. If a field has significant infection, destroy foliage by mowing or flaming to prevent infection of other fields including tomatoes.
Harvest	Foliage and vines should be completely dead and dry before harvest to avoid inoculating tubers. Providing at least 2-3 weeks post-vinekill prior to harvesting will improve skin set and allow many blight infected tubers to develop visual symptoms that can be graded out prior to storage or marketing.
Postharvest	Cool tubers as quickly as possible to 50 degrees and maintain good air circulation. Maintain proper storage temperature depending on variety grown (See Section 10.4). Monitor storage potatoes for infection.
Sanitation	Eliminate cull piles and volunteers before plants emerge in the spring. Infected shoots from these plants can provide initial inoculum for field infection.
Notes	High nitrogen rates can lead to excessive foliage that will prevent adequate airflow and thus slow foliage drying.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.4 Pesticides for Management of Late Blight

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Badge X2 (copper hydroxide, copper oxychloride)	1-4 lb/acre	0	48	1	Copper based products effective in 3/3 trials. Copper based products effective but must be applied often and thoroughly. Copper products may suppress disease under ideal conditions but will not protect under heavy pressure. This is not a substitution for an integrated disease management approach.
Basic Copper 53 (basic copper sulfate)	3-4.7 lb/acre	up to day	48	1	See comment for Badge X2.
Champ WG (copper hydroxide)	1-4 lb/acre	-	48	1	For Champ WG apply 1-1.5 lbs/A where disease is light and up to 3 to 4 lbs/A where disease is more severe. Application of Champ WG at rates and timing recommended for control of Early and Late Blight may provide suppression of Colorado Potato Beetle. See comment for Badge X2.
Copper Sulfate Crystals (copper sulfate pentahydrate)	10 lb/acre	0	24	1	See comment for Badge X2. To enhance vine-kill and suppress late blight
CS 2005 (copper sulfate pentahydrate)	19.2-32 oz/acre	0	48	1	See comment for Badge X2.
Cueva Fungicide Concentrate (copper octanoate)	2 gal/ 50-100 gal water	up to day	48	1	See comment for Badge X2.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	Suppression only.
Double Nickel LC (Bacillus amyloliquefaciens strain D747)	0.5-6 qt/acre	0	4	?	Suppression only.
Nordox 75 WG (cuprous oxide)	1.25-2.5 oz/acre	-	12	1	See comment for Badge X2.
Nu-Cop 50 WP (copper hydroxide)	1-1.5 lb/acre (light infestation); 3-4 lb/acre (heavy infestation)	1	24	2	Apply every 7-10 days when plants are 6 inches high. Copper based products effective in 3/3 trials. Copper based products effective but must be applied often and thoroughly. Copper products may suppress disease under ideal conditions but will not protect under heavy pressure. This is not a substitution for an integrated disease management approach.
Nu-Cop 50DF (copper hydroxide)	1-4 lb/acre	1	48	1	See comment for Badge X2.
Nu-Cop HB (copper hydroxide)	0.5-2 lb/acre	-	48	1	See comment for Badge X2.

Table 12.4 Pesticides for Management of Late Blight

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Optiva (*Bacillus subtilis* str QST 713)	14-24 oz/acre	0	4	?	Suppression only.Repeat on a 5-7 day interval or as needed.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water Curative	0	until dry	3	Hydrogen peroxide products effective in 0/3 trials. Apply at first sign of disease. Spray consecutive applications until control is achieved and then follow directions for preventative treatment. Bee Hazard. This product is toxic to bees exposed to direct contact.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl.oz./100 gal water Preventative	0	until dry	3	Hydrogen peroxide products effective in 0/3 trials.Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce rate to 32 fl oz/100 gal preventative rate after completion of third treatment and maintain 5-day interval spray cycle until harvest. Bee Hazard. This product is toxic to bees exposed to direct contact.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	3	Hydrogen peroxide products effective in 0/3 trials.Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	3	Hydrogen peroxide products effective in 0/3 trials.Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
*Quimag Quimicos Aguila Copper Sulfate Crystal (copper sulfate pentahydrate)	10 lb/acre	-	48	1	See comment for Badge X2. Use alone through harvest to suppress late blight.
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre	0	4	?	Repeat on a 5-7 day interval or as needed.
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.25-1.5 lb/ 20 gal water seed piece dip 0.03-3 lb/ cwt seed seed piece dust	0	4	1	Trichoderma harzianum products effective in 1/1 trial.
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	Repeat on a 5-7 day interval or as needed. For suppression, begin applications of Serenade ASO or Serenade MAX soon after emergence and when conditions are conducive to disease development.
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	See comment for Serenade ASO.

Table 12.4 Pesticides for Management of Late Blight

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Serifel (*Bacillus amyloliquefaciens*)	4-16 oz/acre	0	4	?	
Zonix (*Rhamnolipid Biosurfactant*)	0.5-0.8 oz/ gal	-	4	?	Contact biofungicide that controls disease upon contact with zoospores. Thorough coverage is necessary.

* = Restricted-use pesticide. Restricted-use pesticides can only be purchased by certified applicators and used by certified applicators or someone under the direct supervision of a certified applicator.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2-effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

12.5 Verticillium Wilt, *Verticillium albo-atrum and V. dahliae*

Time for concern: Mid-season to harvest, in cool soils.

Key characteristics: Wilt symptoms result from the growth of the fungi in the water-conducting tissues of the tuber, root and stem. Yellowing, wilting, and defoliation are the first symptoms, which typically occur on one side of a leaf or one side of the plant. These symptoms may be more apparent at higher temperatures when the plants are trying to transport more water. When affected stems are cut diagonally at the base, brown streaks are visible (Reference 55). Infected tubers develop a light brown discoloration of the vascular tissue. Wilting and chlorosis of the foliage is similar to Fusarium wilt. Laboratory isolation of the fungus is necessary for positive identification. Verticillium survive as microsclerotia in the soil. See Cornell general fact sheet (Reference 55).

Yield losses are more severe when lesion nematode (*Pratylenchus penetrans*) is also present, even at low soil population levels; the nematode/verticillium complex is called early dying.

Relative risk: Sandy soil is a risk factor; uncommon in heavier soils of Upstate NY.

Management Option	Recommendation for Verticillium Wilt
Scouting/thresholds	Record the occurrence and severity of Verticillium wilt. Thresholds have not been established for organic production
Crop rotation	Rotation with grains reduces soil populations. The pathogen survives for several years without a host crop and will infect and reproduce on many weeds. Plan a minimum of 3-4 years without tomato, eggplant or pepper and maintain good weed control in rotational crops.
Resistant varieties	For tuber symptoms, late-maturing varieties are more resistant than early-maturing varieties. See Section 6: *Varieties*. Superior is particularly susceptible, while Atlantic is tolerant, Genesee is resistant, and Reba is moderately resistant.
Cultivation/Hilling	Avoid late cultivation and hilling of susceptible varieties, because root pruning increases risk of infection.

12.6 Fusarium Wilt, *F. oxysporum and F. solani*

Time for concern: Mid-season to harvest. Infection is favored by hot weather and high soil moisture.

Key characteristics: Fusarium, a soil borne fungi, can cause a variety of symptoms including tuber lesions and vascular discoloration in tuber, root and stem. Wilt symptoms result from the growth of the fungi in the water-conducting tissues of the root and stem. Wilting and chlorosis of the foliage is similar to Verticillium wilt. Laboratory isolation of the fungus is necessary for positive identification. There are no chemical control options. See Cornell general fact sheet (Reference 55) for photos of symptoms and more information.

Relative risk: Yield loss can be up to 50 % in severely affected fields.

Management Option	Recommendation for Fusarium Wilt
Scouting/thresholds	Record the occurrence and severity of Fusarium wilt. Thresholds have not been established for organic production
Site selection	Avoid fields that have had severe outbreaks in the past.
Crop rotation	Crop rotation is not useful because the fungi survive in the soil for long periods without host plants.
Resistant varieties	No resistant varieties are available. Kenebec is highly susceptible.

12.7 Black Dot Root Rot, *Colletotrichum coccodes*

Time for concern: Growing season and into storage. Disease incidence increases later in the season, when soil temperatures are high. High temperatures and moisture on tuber surfaces promotes disease in storage.

Key characteristics: This fungal disease is also referred to as "black dot" because of the numerous black, fungal structures that appear on tubers, stolons, roots, and stems both above and below ground. Root growth is reduced and appears brown to black in color. Tuber infection appears as brown to gray discoloration over a large part of the tuber surface or as round spots larger than 1/4 inch in diameter. Black dot survives up to 2 years on infected plant debris and soil. See fact sheet (Reference 65), interactive black dot of potato photo (Reference 66) and Michigan State University life cycle (Reference 67).

Relative risk: Black dot root rot occurs sporadically but can result in 75% yield loss in severely infected fields. Can be destructive because it causes symptoms on all plant parts.

Management Option	Recommendation for Black Dot Root Rot
Scouting/thresholds	Record the occurrence and severity of root rot. Thresholds have not been established for organic production
Crop rotation	Minimum 3-4 year rotation that includes a grain crop. Maintain good management of solanaceous weeds in rotational crops. Do not rotate with tomatoes.
Resistant varieties	No resistant varieties are available, but late-maturing varieties are more vulnerable to yield reduction. Varieties that appear to be moderately resistant (based upon tuber ratings) include Eva, Genesee, Keuka Gold, Lehigh, Norland, and Norwis. Varieties that are moderately susceptible to susceptible include Andover, Banana, Chieftain, Monona, Pike, Reba, Superior, and Yukon Gold. See Section 6: Varieties.
Seed selection	Plant phytosanitary certified seed. See Section 7.1: Seed sources.
Site selection	Choose well-drained field if possible.
Postharvest	Deep plowing will bury infected debris and promote decomposition.
Notes	Provide adequate water and fertilizer because crop stress increases vulnerability to black dot.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.7 Pesticides for Management of Black Dot Root Rot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Serifel (*Bacillus amyloliquefaciens*)	4-16 oz/acre	0	4	?	Applications are for the foliar phase of Black Dot.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available

12.8 Canker and Black Scurf, *Rhizoctonia solani*

Time for concern: Growing season. Cool wet soils favor disease development.

Key characteristics: This fungus causes a variety of symptoms on tubers including cracking, malformation, and russeting. The 'black scurf' symptom found on infected tubers appears as numerous dark, hard reproductive structures, called sclerotia. The sclerotia may be flat and superficial or large, irregular, and lumpy. Sclerotia on stored tubers do not cause damage or spread the disease in storage. However, sclerotia in soil or on seed pieces can germinate and infect young, susceptible sprouts and stolons, causing lesions, or cankers. In cool wet soils, when plants are growing slowly, disease can progress rapidly, causing reduced stands and stunted plants. See Cornell fact sheet (Reference 68), Michigan fact sheet (Reference 69), and interactive black scurf potato photo (Reference 66).

Relative risk: This disease is very common in New York.

Management Option	Recommendation for Canker and Black Scurf
Scouting/thresholds	Record the occurrence and severity of canker. Thresholds have not been established for organic production
Site selection	Heavy, poorly drained soils should be avoided.
Crop rotation	Minimum three-year rotation to corn or grain crops. Plant a grass or cereal green manure such as a sorghum-sudan grass hybrid or Japanese millet the year before potatoes are grown.
Cover crops	One Michigan State study found reduced Rhizoctonia incidence in a potato crop planted after incorporating a spring brassica cover crop.
Resistant varieties	No resistant varieties are available.
Seed selection	Plant phytosanitary certified seed (See Section 7.1: Seed sources). Inoculum can be introduced into fields on potato seed tubers. See Section 7: Planting methods.
Planting	Plant in warm soils and plant shallowly to encourage rapid emergence. Best if soil organic matter is decomposed before planting.
Vine killing	Minimize the time tubers stay in the soil after vine death.
Sanitation	Inoculum can also be introduced to the fields by contaminated soil.
Notes	If conditions are cold and wet, potatoes should be planted shallowly or planted deeply and covered shallowly. This encourages rapid emergence and reduces the chance of damage to new sprouts, 'sprout burn'

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.8 Pesticides for Management of Canker and Black scurf

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	1-12 oz/acre soil treatment 3-12 oz/acre soil drench 2-18 cwt of seed seed treatment	up to day	1 or until dry	3	Soil treatment at planting. *Streptomyces lydicus* products effective in 0/6 trials.
Actinovate STP (*Streptomyces lydicus*)	4-32 cwt of seed seed treatment	-	1 or until dry	?	
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band 2.5-5 lb/acre broadcast	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil drench	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.
Regalia (*Reynoutria sachalinensis*)	1-3 qt/100 gal water soil drench 1-4 qt/acre in-furrow treatment	0	4	?	
RootShield Granules (*Trichoderma harzianum*)	2.5-6 half acre in-furrow treatment	-	0	?	

Table 12.8 Pesticides for Management of Canker and Black scurf					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.03-3 lb/ cwt seed seed piece dust 16-32 oz/acre in-furrow treatment	0	4	3	For use in planter box only. Trichoderma based products effective in 0/4 trials. Do not apply when above-ground harvestable food commodities are present.
RootShield WP (*Trichoderma harzianum*)	0.03-3 oz/ cwt seed seed treatment 16-32 oz/acre in-furrow treatment	-	until dry	3	For use in planter box only. Trichoderma based products effective in 0/4 trials.
Serenade Soil[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre soil treatment	0	4	?	Soil drench or in-furrow.
Soilgard (*Gliocladium virens*)	2-10 lb/acre soil treatment	0	until dry	?	
Taegro (*Bacillus subtilis*)	3 tsp/gal water seed piece treatment 2.6 oz/100 gal water in-furrow treatment	-	24	?	Dip tubers for 10 to 30 minutes before planting. For best results, make two or three applications spaced one week apart. Soil drench or over furrow at time of planting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment 25 fl oz/ 200 gal water/1000 sq ft of soil soil treatment	up to day	0	?	Apply at 25-100 gallons of solution per acre row. Soil treatment prior to seeding/ transplanting. Soil treatment with established plants.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1]Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

12.9 Botrytis Vine Rot, *Botrytis cinerea*

Time for concern: Growing season, especially under wet conditions and prolific vine growth.

Key characteristics: This fungus infects dead tissue and can be seen as a fuzzy, gray growth on dead blossoms or senescent leaves. It is sometimes mistaken for late blight. 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. See Canada fact sheet (Reference 70).

Relative Risk: Occurs sporadically and usually does not result in significant yield loss.

Management Option	Recommendation for Botrytis Vine Rot
Scouting/thresholds	Record the occurrence and severity of Botrytis vine rot if it will cause disease problems within the crop rotation. Thresholds have not been established for organic production
Site selection	Avoid planting in fields with soils that drain poorly. Avoid areas where foliage remains wet from dew for long periods. Fields surrounded by trees that shade and slow air movement, or those remaining damp late into the morning are at higher risk.

Management Option	Recommendation for Botrytis Vine Rot
Resistant varieties	No resistant varieties are available.
Crop rotation, Seed selection, Post-harvest, and Sanitation	These are not currently viable management options.
Notes	Nitrogen rates that result in excess vine growth aggravate this disease.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.9 Pesticides for Management of Botrytis Vine Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	3-12 oz/acre	up to day	1 or until dry	?	Label recommends using a spreader sticker for foliar applications.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre	0	4	?	
GreenCure (potassium bicarbonate)	1-2 T/450 sq ft	-	-	?	
Milstop (potassium bicarbonate)	2.5-5 lb/acre	0	1	?	
Optiva (*Bacillus subtilis* str QST 713)	14-24 oz/acre	0	4	?	Repeat on a 7-10 day interval or as needed.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Prestop (*Gliocladium catenulatum*)	3.5 oz/ 5 gal water foliar spray	-	0	?	Apply only when no above-ground harvestable food commodities are present.
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre	0	4	?	Repeat on a 5-7 day interval or as needed.
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	Repeat on a 7-10 day interval or as needed.

Table 12.9 Pesticides for Management of Botrytis Vine Rot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	Repeat on a 7-10 day interval or as needed.
Serenade Opti[1] (*Bacillus subtilis* str QST 713)	14-20 oz/acre	0	4	?	Repeat on a 7-10 day interval or as needed.
Serifel (*Bacillus amyloliquefaciens*)	4-16 oz/acre	0	4	?	
Trilogy (neem oil)	0.5-1% solution in 25-100 gal of water/acre	up to day	4	?	Maximum labeled rate of 2 gallons/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restrictedentry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

12.10 White Mold, *Sclerotinia sclerotiorum*

Time for concern: Mid-season to harvest. Favored by wet or humid plant canopy and poor air circulation.

Key characteristics: The fungus is soil borne and generally infects stems at the soil line, but the infection may occur on any part of the plant. Symptoms include dense, cottony, white growth and the production of hard, black, irregularly shaped sclerotia on infected tissue. This disease is not common on potatoes in New York. See Michigan State fact sheet (Reference 71).

Relative risk: White mold is a risk if soil is infested with sclerotia, in wet seasons and with excessive irrigation.

Management Option	Recommendation for White Mold
Scouting/thresholds	Scout the previous crop in the field prior to harvest to determine the need for treatment with Contans WG after harvest to reduce overwintering inoculum. Keep an accurate history of white mold incidence and severity in all fields.
Coverage	The best coverage can be obtained by using a minimum of 50 gallons per acre and high pressure (100 to 200 psi). Thoroughly cover initials, buds, and blossoms.
Crop rotation	Rotation with grains reduces soil populations and is an important management tool. Avoid rotations with beans. Plant potatoes only every 5th year if white mold is a problem. If there is a field history of white mold, potatoes should not be preceded by a bean (including soybeans), tomato, lettuce, or crucifer crops.
Resistant varieties	No resistant varieties are available.
Site selection	Avoid planting in shaded areas and in small fields surrounded by trees; do not plant in fields that drain poorly or have a history of severe white mold.
Planting	Plant rows in an east-west direction.
Fertilization	Avoid over-fertilization.
Irrigation	Avoid over watering.
Postharvest	Incorporate crop debris immediately following harvest to allow soil microorganisms the opportunity to feed on the survival structures called sclerotia.

Management Option	Recommendation for White Mold
Sanitation	Manage weed hosts such as lambsquarters and pigweed.
Note(s)	The disease tends to be worse in fields where there is poor weed management, leaves have mechanical damage or pesticide injury, and where dead leaves are on the ground. The fungus can grow on dead and living material.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.10 Pesticides for Management of White Mold

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	1-12 oz/acre soil treatment 3-12 oz/acre soil treatment 2-18 oz/cwt of seed seed treatment	up to day	1 or until dry	?	Soil treatment at planting Soil treatment in season.
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/1000 row feet in-furrow treatment	-	1	?	
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	2.5-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band 2.5-5 lb/acre broadcast	-	4	?	
Contans WG (*Coniothyrium minitans*)	1-4 lb/acre soil treatment	-	4	1	Effective in 1/1 trial against sclerotia in the soil. Apply Contans to Sclerotinia infested ground immediately following harvest at 1 lb/A and incorporate the debris into the soil and/or apply at 2 lb/A to a planted crop right after planting followed by shallow incorporation (or irrigate) to about a 1 to 2 inch depth. Do not turn the soil after application of Contans to avoid bringing untreated soil that contains viable sclerotia near the surface. See label for specific storage requirements.

Table 12.10 Pesticides for Management of White Mold

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	Apply at or immediately following planting (but before plant emergence) as a banded seedline treatment 4 to 6 inches wide. Make second application at thinning or cultivation in sufficient water and multiple nozzles to ensure thorough coverage of lower leaves and surrounding soil surface. Incorporation with light irrigation after application may improve disease control.Repeat at 10-14 day intervals if conditions promoting disease persist. Foliar spray or soil treatment.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre foliar spray	0	4	?	See comment for Double Nickel 55.
Optiva (*Bacillus subtilis* str QST 713)	14-24 oz/acre	0	4	?	Suppression only. Repeat on a 7-10 day interval or as needed. Begin application soon after emergence or transplant and when conditions are conducive to disease development.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre in-furrow treatment	0	4	?	
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	
Serenade Opti[1] (*Bacillus subtilis* str QST 713)	14-20 oz/acre	0	4	?	Repeat on a 7-10 day interval or as needed.
Serifel (*Bacillus amyloliquefaciens*)	4-16 oz/acre	0	4	?	

Table 12.10 Pesticides for Management of White Mold					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Trilogy (neem oil)	0.5-1% solution in 25-100 gal of water/acre	up to day	4	?	Maximum labeled rate of 2 gallons/acre/ application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

12.11 Potato Common Scab, *Streptomyces scabies* and *S. acidiscabies*

Time for concern: Flower to end of season. Thought to be more prevalent during dry weather.

Key characteristics: Both species of Streptomyces cause similar symptoms that range from superficial russeting to deep pitting. Bacteria survive in the soil, in cull potatoes left in the field and on infected seed pieces in storage. Disease does not progress in storage but the pathogen infects newly planted tubers through the lenticels or through wounds. The severity of common scab is significantly reduced when soil pH is maintained below 5.2. See Cornell fact sheet (Reference 72).

Relative risk: Most common on soils with pH 5.5-7.5; usually does not reduce yields but cosmetic damage can significantly affect marketability, especially in tablestock potatoes.

Management Option	Recommendation for Common Scab
Scouting/thresholds	No thresholds are available. Look for and keep a record of disease incidence in late August and at harvest.
Site selection	Avoid fields with a history of scab. Light-textured soils favor scab infection. Maintaining pH levels below 5.2 will prevent common scab, although this practice can make nutrient management and crop rotations difficult and may limit crop diversity. Although severe scab occurs at high soil pH, Streptomyces acidiscabies can occur in soils with a pH below 5.2.
Cover crops	There is no evidence that planting and plowing under a legume cover crop prior to planting potatoes increases the incidence of potato scab. Biofumigant cover crops, such as brassicas, may suppress scab.
Crop rotation	Rotate with alfalfa, rye, soybeans and corn. Rotate with green manure crops such as rye, millet and oats. Do not rotate with common scab hosts such as spinach, turnip, parsnip, radish, beet, and carrot.
Resistant varieties	Planting resistant or tolerant varieties in fields where scab has been a problem is useful, but not sufficient to prevent scab under high disease pressure. Superior is the standard for resistance in the Northeast. Other very resistant, tolerant, resistant or moderately resistant varieties include Andover, Atlantic, Carola, Chieftain, Eva, Genesee, Keuka Gold, Lehigh, Reba, Red Norland, Salem, Yukon Gold.
Seed selection	Avoid planting scab-infested seed.
Irrigation	Maintain moisture during the six weeks following tuberization.
Organic matter management	Warnings against the use of manure and legume green manures that appear in guidelines for conventional potato production do not seem to apply in organic production, perhaps due to the differences in microbial communities and the way organically and conventionally managed soils assimilate new additions of organic matter. Manure from cows fed infected tubers can spread the disease because common scab bacteria can survive an animal’s digestive track.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.11 Pesticides for Management of Common Scab

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Regalia (Reynoutria sachalinensis)	1-3 qt/100 gal water soil drench 1-4 qt/acre in-furrow treatment	0	4	?	
Trilogy (neem oil)	0.5-1% solution in 25-100 gal of water/acre	up to day	4	?	Maximum labeled rate of 2 gallons/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

12.12 Bacterial Ring Rot, *Clavibacter michiganensis* subsp. *sepedonicus*

Time for concern: Seed purchase, planting, throughout season, and at harvest.

Key characteristics: When infected tubers are cut crosswise, a creamy yellow to brown breakdown of the vascular ring is observed. In severe infections, squeezing the infected tuber causes a cream-colored, cheesy exudate to ooze from the vascular ring. Secondary organisms attack infected tubers in storage and may cause skin cracks and a reddish brown discoloration. Symptoms are not always dramatic but laboratory tests should be done if presence of this bacterium is suspected. See Cornell fact sheet (Reference 55) and Ohio State fact sheet (Reference 75) for photos and more information.

Relative risk: Rarely seen in New York; serious damage when present because it can spread rapidly and cause significant losses. There is zero tolerance for this bacterium in seed potatoes. Environmental conditions are not as important in disease development as clean seed and good sanitation practices.

Management Option	Recommendation for Bacterial Ring Rot
Scouting/thresholds	Record the occurrence and severity of bacterial ring rot. No thresholds have been established for organic production.
Resistant varieties	No resistant varieties are available.

Management Option	Recommendation for Bacterial Ring Rot
Seed selection/treatment	This is a seed borne disease, therefore using phytosanitary certified seed is key to preventing outbreaks (see Section 7.1: Seed sources). Serious crop losses can result if infected seed is used because the pathogen is readily spread during seed cutting and planting operations.
Planting	Disinfect equipment and containers between seed lots and periodically during planting operations. See Table 10.3.1: Equipment and Storage Facility Disinfectants. Even healthy seed can be infected by contaminated equipment.
Sanitation	All tuber handling equipment and storage areas must be disinfected if this disease occurs. See Table 10.3.1: Equipment and Storage Facility Disinfectants.
Crop rotation, site selection	These are not currently viable management options.

12.13 Pink Rot, *Phytophthora erythroseptica*

Time for concern: Growing season through marketing. Disease development is favored by cool weather and excessive soil moisture. Infection occurs early in the season; symptoms appear in late August.

Key characteristics: External symptoms on tubers appear as decay around the stem end or eyes and lenticels. The infected area turns purple to dark brown with a black band. When cut, the infected tissue turns pink in a matter of minutes, then darkens to brown and finally to black. This soil borne fungus is common in many soils but causes more damage in areas that stay wet. See Cornell fact sheet (Reference 55), and update (Reference 76), Michigan fact sheet (Reference 77) and (Reference 78).

Relative risk: Pink rot can be frequent and serious in low, wet areas.

Management Option	Recommendation for Pink Rot
Scouting/thresholds	Thresholds have not been established for organic production. Decay originates at stem base and progresses upward; begin looking in late August. Keep track of fields with a history of pink rot.
Crop rotation	Use 4 year crop rotations with non-host plants including legumes, field corn, sweet corn, and onion. The pathogen has been recovered from the roots of small grains.
Site selection	This disease is favored by cool weather and wet soils. Avoid planting in poorly drained areas.
Resistant varieties	No resistant varieties are available. Varieties that appear to be moderately resistant (based upon tuber inoculation tests) include Andover, Atlantic, Keuka Gold, Marcy, Norwis, Pike, Snowden, and Superior. Varieties that are moderately susceptible or susceptible include Allegany, Chieftain, Eva, Lehigh, Norland, Reba, and Yukon Gold. See Table 6.1.2.
Seed selection/treatment	Plant phytosanitary certified seed (See Section 7.1: Seed sources).
Irrigation	Avoid over-irrigation and ponding of water in the field.
Weed management	Nightshade and kochia host pink rot.
Harvest	Harvest when tuber pulp temperatures are lower than 65°. Avoid wounding during harvest.
Postharvest	This pathogen will spread in storage if tubers are not kept dry. If pink rot is found in storage, make a note of field where that crop was grown.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.13 Pesticides for Management of Pink Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	1-12 oz/acre soil treatment 3-12 oz/acre soil treatment 2-18 cwt of seed seed treatment	up to day	1 or until dry	?	Soil treatment at planting. Soil treatment in season.
Actinovate STP (*Streptomyces lydicus*)	4-32 cwt of seed seed treatment	-	1 or until dry	?	
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band 2.5-5 lb/acre broadcast	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil drench	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.
Regalia (*Reynoutria sachalinensis*)	1-3 qt/100 gal water soil drench	0	4	?	
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre in-furrow treatment	0	4	?	

Table 12.13 Pesticides for Management of Pink Rot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	16-32 oz/acre in-furrow treatment	0	4	?	Do not apply when above-ground harvestable food commodities are present.
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.25-1.5 lb/ 20 gal water seed piece dip	0	4	?	
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.03-3 lb/ cwt seed seed piece dust	0	4	?	
Serenade Soil[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre soil treatment	0	4	?	Soil drench or in-furrow.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment	up to day	0	?	Apply at 25-100 gallons of solution per acre row. Soil treatment prior to seeding/ transplanting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl. oz/ 200 gal water/ 1000 sq ft soil treated soil treatment	up to day	0	?	Soil treatment with established plants.
Zonix (Rhamnolipid Biosurfactant)	0.5-0.8 oz/ gal soil treatment	-	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

12.14 Powdery Scab, *Spongospora subterranean*

Time for concern: Growing season through marketing. Infection favored by high soil moisture and low soil temperature (58-68°F).

Key characteristics: Lesions are similar to common scab lesions, but are usually smaller and more uniform in size. Lesions are first visible as purple spots on the tuber surface then as cankers without spore masses. Mature spore masses appear as raised olive green to brown areas inside the canker and have a powdery texture. Small root galls also develop. This protozoan survives on seed and in soil and can vector potato Mop Top virus. See Cornell fact sheet (Reference 55) and University of Maine life cycle (Reference 79)

Relative risk: This is a less critical disease for potatoes in New York.

Management Option	Recommendation for Powdery Scab
Scouting/thresholds	Record the occurrence and severity of powdery scab. Thresholds have not been established for organic production
Site selection	Avoid planting in low spots with poor drainage and wet soils. Powdery scab can occur over a wider pH range than common scab.
Resistant varieties	No resistant varieties are available. Red, white and yellow skinned varieties are more susceptible.
Crop rotation	Select a field with no history of powdery scab and grow potatoes only every 4th or 5th year. Avoid pepper, tomato and solanaceous weeds.
Seed selection/treatment	Plant phytosanitary certified seed (See Section 7.1: Seed sources).

Management Option	Recommendation for Powdery Scab
Postharvest and sanitation	These are not currently viable management options.
Notes	Zinc foliar nutrients can reduce disease incidence.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Powdery Scab					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.
Trilogy (neem oil)	0.5-1% solution in 25-100 gal of water/acre	up to day	4	?	Maximum labeled rate of 2 gallons/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

12.15 Leak, *Pythium* spp.

Time for concern: Infection usually occurs at harvest, especially when internal pulp temperatures are above 65˚F

Key characteristics: This soil borne fungus infects potato tubers through wounds at harvest. External symptoms consist of gray to brown lesions with water-soaked appearance around wounds. Tubers become rubbery or spongy and exude a liquid when squeezed. If advanced, then secondary bacteria are already decaying tissue and "shell rot" results. See Cornell fact sheet (Reference 55) and update (Reference 76).

Relative risk: Annual occurrence and especially serious if tubers are dug when soil temperatures are high. Avoid digging from soils that are waterlogged.

Management Option	Recommendation for Pythium Leak
Scouting/thresholds	If fields have been flooded, scout for infection. Thresholds have not been established for organic production
Site selection	Select fields with low levels of this pathogen, as determined by pre-plant soil sampling.
Resistant varieties	Snowden and Marcy show some tolerance.

Management Option	Recommendation for Pythium Leak
Crop rotation	Rotate out of potatoes at least 4 years.
Seed selection/treatment	Plant phytosanitary certified seed. See 7.1: Seed sources.
Harvest	Avoid harvesting immature tubers during hot or wet weather. Avoid wounding tubers during harvest since this is the only means of entry for this Oomycete.
Postharvest	Keep storage temperature low (40° to 45°F) if the disease is detected.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.15 Pesticides for Management of Pythium Leak

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	1-12 oz/acre soil treatment 3-12 oz/acre soil treatment 2-18 cwt of seed seed treatment	Up to day	1 or until dry	?	Soil treatment at planting. Soil treatment in season.
Actinovate STP (*Streptomyces lydicus*)	4-32 oz/cwt of seed seed treatment	-	1 or until dry	?	
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/1000 row feet in-furrow treatment 2.5-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	1.5-3 oz/ 1000 row feet in-furrow treatment 2.5-3 lb/acre band 2.5-5 lb/acre broadcast	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water initial/curative 0.25-0.33 fl.oz./ gal water weekly/preventative	-	until dry	?	Foliar application. For initial or curative use, apply 1 fl. oz./gal rate for 1 to 3 consecutive days. Then follow weekly/preventative treatment directions. For weekly or preventative treatments, apply 0.25-0.33 fl. oz/ gal. every five to seven days. At first sign of disease, spray daily with 1 fl. oz./gal for three consecutive days. Then return to preventative treatment schedule and rate.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal water	-	until dry	?	Soil drench. Use at time of seeding or transplanting and periodically as a drench. Apply until soil is saturated.

Table 12.15 Pesticides for Management of Pythium Leak					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI² (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil drench	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.
Regalia (*Reynoutria sachalinensis*)	1-3 qt/100 gal water soil drench 1-4 qt/acre in-furrow	0	4	?	
RootShield Granules (*Trichoderma harzianum*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
RootShield PLUS+ WP (*Trichoderma harzianum, Trichoderma virens*)	0.03-3 lb/ cwt seed seed piece dust 16-32 oz/acre in-furrow treatment	0	4	?	Do not apply when above-ground harvestable food commodities are present.
RootShield WP (*Trichoderma harzianum*)	0.03-3 oz/ cwt seed seed treatment 16-32 oz/acre in-furrow treatment	-	until dry	?	For use in planter box only.
Serenade Soil[1] *(Bacillus subtilis* str QST 713)	2-6 qt/acre soil treatment	0	4	?	Soil drench or in-furrow.
Soilgard (*Gliocladium virens*)	2-10 lb/acre soil treatment	0	until dry	?	
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water soil treatment 25 fl. oz./ 200 gal water/ 1000 sq ft soil treated soil treatment	up to day	0	?	Apply at 25-100 gallons of solution per acre row. Soil treatment prior to seeding/ transplanting. Soil treatment with established plants.
Zonix (Rhamnolipid Biosurfactant)	0.5-0.8 oz/ gal soil treatment	-	4	?	Soil drench or in-furrow.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [1] Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

12.16 Silver Scurf, *Helminthosporium solani*

Time for concern: At planting, through growing season, post harvest and storage. Warm, wet soil favors sporulation and disease spread in the field. Post harvest handling and first weeks of storage are the primary times of infection and spread of silver scurf. Warm pulp temperatures and high relative humidity greatly favor spread of silver scurf in storage

Key characteristics: This seed and soil borne fungus infects only the skin of the potato. Symptoms appear at the stolon end as small, pale, brown spots. Severe browning of the surface layers of tubers may occur, followed by sloughing-off of the outer layers of the periderm. Lesions are circular. The silvery appearance of older lesions is most obvious when the tubers are wet. See the Pacific Northwest fact sheet(Reference 81), Cornell fact sheet(Reference 82) and interactive silver scurf potato photo (Reference 66).

Relative risk: This disease occurs annually and is especially noticeable on red, blue and purple-skinned varieties.

Management Option	Recommendation for Silver Scurf
Scouting/thresholds	Lesions may be difficult to detect at harvest, but applying moisture to the tuber surface reveals a silvery sheen. Tubers often develop symptoms in storage along with extensive sporulation.
Resistant varieties	No resistant varieties are available, but thin-skinned varieties are more susceptible and blemishes on red and purple-skinned varieties are very noticeable.
Seed selection/treatment	Infected seed pieces are the primary source of inoculum. Plant phytosanitary certified seed (see Section 7.1: *Seed sources*). Seed can be tested for presence of silver scurf.
Harvest	Harvest tubers as soon as they are mature. Vine killing 2-3 weeks before harvest showed less silver scurf than when tubers were harvested green.
Postharvest	Disinfect storages to kill spores that remain from the previous years' crop. High relative humidity (90-95%) and warm temperatures (47-56˚F) favor the development and spread of silver scurf in storage. Lowering the temperature to 39-45˚F and the relative humidity to 85-90% as quickly as possible in the first month of storage can delay sporulation. Monitor storage conditions to eliminate free moisture on tuber surfaces. For more information on storage conditions, see the Pacific Northwest Extension fact sheet (Reference 81)
Crop rotation	Soil-borne inoculum has been implicated in the seasonal occurrence of silver scurf. Maintain minimum of 2 year rotation of potatoes.
Sanitation	Clean and disinfect storage facilities (see 10.3.1: Equipment and Storage Facility Disinfectants).

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.16 Pesticides for Postharvest Treatment of Silver Scurf

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI (Days)	REI (Hours)	Efficacy	Comments
Decco Aerosol 100 for Treatment of Potato in Storage (clove oil)	1 gal/ 900 cwt potatoes	-	-	1	25(b) pesticide. Effective in 1/1 trial. Designed for use through Forced Air Distribution System. Usually performed by lisenced applicators.
Prestop (Gliocladium catenulatum)	0.75% suspension post-harvest drench	-	0	?	Dip or spray bulbs and tubers with suspension before storage.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available

1 Check with your certifier before use. For potatoes sold as a food crop, non-organically produced clove oil is not on the approved products list for post harvest use; therefore certified organic clove oil must be used. For post harvest use on potatoes sold as seed, clove oil must be 100% pure, but does not need to be certified organic. (National Organic Program section 205.606) (Reference 44).

12.17 Viruses of Potatoes

Time for Concern: Throughout the growing season and into storage

Key Characteristics: Virus infections can cause distorted growth, stunting, distortions in leaf coloration, yield reductions, external and internal tuber necrosis and small misshapen tubers. See Cornell fact sheet(Reference 84) and updated fact sheet (Reference 85B).

Relative risk: The PVY group is now considered one of the most prevalent and important viruses in potatoes.

Management Option	Recommendation for Viruses
Seed selection/treatment	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. See the New York State Seed Directory Maine Seed Directory and the Colorado Seed Directory. (References 32-34)
Site selection	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.
Sanitation	Eliminate weeds in and around fields that can serve as the primary inoculum source early in the season. Cull symptomatic plants from the field as soon as they are discovered to reduce transmission of viruses.
Compounds	The focus for virus control is mitigating the transmission and spread of viruses by the aphid vectors. It can take less than a minute of probing on top leaf surfaces for aphids to acquire or inoculate potato plants with a virus. Repeated foliar applications of Stylet oil impede virus transmission by blocking the virus from entering or exiting the plant through the aphid's mouthparts.

Table 12.17.1 Virus Diseases of Potatoes.

Disease/Symptoms	Spread by	Management options	Resistant Varieties	Notes
Major Potato Viruses				
Potato Leaf Roll Virus (PLRV) Primary infection: upper leaves pale, upright, rolled; lower leaves may be asymptomatic. Secondary infection: lower leaves severely rolled and general plant stunting and chlorosis. Net necrosis on tubers in some varieties. See Cornell photos of primary secondary and tuber infections (Reference 85) and factsheet (Reference 85B).	Aphids, tuber seedpieces, volunteer potatoes and some weed hosts	Plant phytosanitary certified seed; use stylet oil to limit virus transmission	Resistant: Atlantic Moderately resistant: Chieftain and Norland	One of the three most important viruses affecting potatoes.
Potato Virus Y (PVY) Symptoms vary, depending on strains and interaction with other viruses, from rugose mosaic, general mosaic, and veinal necrosis to severe necrosis. The common strain = PVY^{O}. The tuber necrotic strain = PVY^{NTN}. See Cornell photo (Reference 85B).	Aphids, tuber seedpiece, volunteer potato plants, weed hosts.	Plant phytosanitary certified seed; use stylet oil to limit virus transmission	Some varieties are hypersensitive and display field resistance. Some resistance or tolerance: Eva, Dk Red Norland, Belrus, HiLite Russet, Kennebec, Monona, Norwis and Sebago. (Reference 85C). Yukon Gold is very susceptible to PVY^{NTN}.	The most prevalent virus infecting potato. Can interact with PVA and PVX to create greater yield losses.

Table 12.17.1 Virus Diseases of Potatoes.

Disease/Symptoms	Spread by	Management options	Resistant Varieties	Notes
Potato Virus X (PVX) Plants can show no symptoms and symptoms from an interaction with PVA and PVY. See fact sheet (Reference 85B).	Tuber seedpiece and mechanical activity. Tobacco, pepper and tomato also host this virus.	Plant high quality phytosanitary certified seed.	Some varieties with resistance or tolerance are HiLite Russet, Atlantic, Norwis, and Sebago (Reference 85C).	A widely distributed virus. Often interacts with PVA and PVY, making symptoms difficult to discern.
Minor Potato Viruses				
Potato Virus A (PVA) Symptoms range from mild mosaic to mixed symptoms when interact with other viruses.	Aphids, tuber seedpiece, volunteer potato plants, some weed hosts	Plant high quality phytosanitary certified seed, use stylet oil to limit virus transmission; plant resistant varieties.	Katahdin, Kennebec, Sebago reported to show field resistance.	
Potato Viruses S and M (PVS and PVM) See fact sheet (Reference 85B).	Tuber seedpiece and aphids			These viruses may be most important when present with other viruses.
Alfalfa Mosaic Virus (AMV) Produces characteristic calico symptoms. See Cornell photo (Reference 85) and fact sheet (Reference 85B).	Many aphid species, legume crops and tuber seedpieces	Concern when adjacent alfalfa or clover fields are cut and infective aphids fly over to potatoes.		Does not result in significant yield losses.
Potato Spindle Tuber Viroid (PSTV) Tubers are spindle shaped or oblong; plants appear stiff, with unusual upright growth pattern. See Cornell photo and plant symptoms (Reference 85) and factsheet (Reference 85B).	Tuber seedpiece, mechanically; also through pollen and true seed. Insects can transmit, but not as important.			Use certified seed. Viroid has not occurred in NYS for the past 15 years.
Potato Mop Top Virus See photo (Reference 85B)	Powdery Scab pathogen, *Spongospora subterranea*			The virus currently does not occur in NYS, although the fungal vector does.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 12.17 Pesticides for Management of Viruses

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Organic JMS Stylet-Oil (parrafinic oil)	3 qt/100 gal water	0	4	?	Only labeled for control of potato leafroll virus and potato virus Y. Thorough coverage of upper leaf surfaces is important. Spray weekly through harvest. Expect to work best on viruses that are transmitted by aphids in a persistent manner like potato leaf roll virus. Do not apply within 10-14 days of a sulfur application.
PureSpray Green (white mineral oil)	0.75 gal/acre	up to day	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

13. Nematode Management

13.1 Northern Root-Knot (*Meloidogyne hapla*) and Root-Lesion (*Pratylenchus spp.*)

Time for concern: Before and during planting. Long-term planning is required for sustainable management.

Key characteristics: The populations and damage of lesion nematodes has steadily increased in recent years, probably due to the increased use of grains as cover and rotational crops to improve soil quality and health. Potato serves as a good host for both nematodes and will tend to increase populations when planted in infested fields. Plants heavily infested with either nematode do not exhibit diagnostic above ground symptoms, but only general stunting and uneven growth. However, diagnostic symptoms are found on roots as galls and brown - black, narrow lesions caused by the root-knot and lesion nematodes, respectively. The presence of nematodes in roots or in soil around roots is the only definitive evidence of their involvement. See Cornell fact sheet(Reference 86).

Risk assessment: Both the root-knot nematode and the lesion nematode are widespread in New York soils and at high populations can cause significant yield losses for potatoes. Lesion nematode even at low soil population levels interacts with *Verticillium dahliae* to cause early dying disease.

Management Option	Recommendation for Root-Knot and Root-Lesion Nematodes
Scouting/thresholds	Record symptoms of damage and assay roots and soil for the presence and density of nematodes. Threshold level of root-knot nematode on potatoes in organic soil is between 4-8 eggs/cc soil. A density as low as 1 lesion nematode/cc soil has caused damage to potatoes. Use a soil bioassay with lettuce and/or soybean to assess soil root-knot and root-lesion nematode infestation levels, respectively. Or, submit the soil sample(s) for nematode analysis at a public or private nematology lab (Reference 87). See Section 4: Field Selection for more information as well as the following Cornell publications for instructions: Soil Sampling for Plant Parasitic Nematodes (Reference 88) Visual Assessment of Root-Knot Nematode Soil Infestation Levels Using a Lettuce Bioassay (Reference 89) A Soil Bioassay for the Visual Assessment of Soil Infestations of Lesion Nematode (Reference 90).

Management Option	Recommendation for Root-Knot and Root-Lesion Nematodes
Crop rotation	Both nematodes have a wide host range, thus it is difficult to design a practical, economic, and effective crop rotation. Grain crops such as wheat, rye, oats, barley, corn, and sudangrass are not hosts for the root-knot nematode and therefore effective at reducing the nematode population. However, onion, carrot, lettuce, celery, soybeans, clover, alfalfa, and beans are good hosts to the root-knot nematode. All grain crops are good hosts to lesion nematode, except a number of cultivars of ryegrass and forge pearl millet. In addition, most cultivars of clovers, soybean, alfalfa, vetch and beans are also good hosts to lesion nematode. If both root-lesion and root-knot nematodes are present in the same field then rotation with a grain crop may increase the root-lesion nematode population to a damaging level for the next crop. In addition to grain crops, root-lesion nematode has over 400 hosts including many vegetables that are planted in rotation with potatoes thus making it difficult to manage root-lesion nematode strictly using a crop rotation. Depending on the size of the infested site, marigold varieties such as 'Polynema' and 'Nemagone' are very effective at reducing nematode populations, where marigold can be established successfully.
Site selection	Damage from these nematodes is especially high on sandy and organic soils as well as in poor health soils.
Resistant varieties	No resistant varieties are available.
Seed selection/treatment	Select vigorous, phytosanitary certified seed pieces (see Section 7.1: Seed sources). Nematodes can be seed born making infested seed less vigorous.
Cover crops	Grain crops are "non-hosts" to the northern root-knot nematode (Meloidogyne hapla), the only root-knot nematode species found outdoors in NY. Bio-fumigant cover crops can be effective against both the root-knot and lesion nematodes when incorporated as green manures (before drying and/or freezing). Soil incorporation of green manure of sudangrass before the first frost will reduce the population of both nematodes and their damage to potatoes. Certain white clover and flax lines have given similar results. Also, cruciferous crops including rapeseed, mustard, oil seed radish and others are effective in reducing populations of these nematodes when incorporated as green manures in warm soils.
Biofumigant cover crops	Grain cover crops such as winter rye and oat are poor or non-hosts for the root-knot nematode, thus they are effective at reducing the population. Cover crops with a biofumigant effect, used as green manure are best used for managing root-lesion nematode and will also reduce root-knot nematode populations. It is important to note that many biofumigant crops including Sudangrass, white mustard, and rapeseed are hosts to root-lesion nematode and will increase the population until they are incorporated into the soil as a green manure at which point their decomposition products are toxic to nematodes. Research has suggested that Sudangrass hybrid 'Trudan 8' can be used effectively as a biofumigant to reduce root-lesion nematode populations. Cover crops such as forage pearl millet 'CFPM 101' and 'Tifgrain 102', rapeseed 'Dwarf Essex', and ryegrass 'Pennant' are poor hosts, and thus will limit the build-up or reduce root-lesion nematode populations when used as a "standard" cover crop.
Sanitation	Wash equipment after use in infested fields. Avoid moving soil from infested fields to uninfested fields via equipment and vehicles, etc. Also limit/avoid surface run-off from infested fields.
Weed Control	Many common weeds including lambsquarters, redroot pigweed, common purslane, common ragweed, common dandelion and wild mustard are hosts to root-lesion nematode; therefore effective weed management is also important.

At the time this guide was produced, the following materials were legal in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS website) http://pims.psur.cornell.edu/ (Reference 3). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 13 Pesticides for Management of Nematodes

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
DiTera DF (*Myrothecium verrucaria*)	13-100 lb/acre	-	4	?	
Ecozin Plus 1.2% ME (azadirachtin)	25-56 oz/acre soil drench	0	4	?	
MeloCon (*Paecilomyces lilacinus* str. 251)	6-9 lb/acre	-	4	?	Pre-plant or drench at transplant.
Molt-X (azadirachtin)	15 oz/acre	0	4	?	Apply in sufficient amount of water to penetrate in the soil to a depth of 12 inches. Repeat applications every 3 or 4 weeks or as needed.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

14. Nonpathogenic Disorders

Environmental factors can cause symptoms that appear to be diseases but are actually not caused by a pathogen or insect. Table 14.1.1 provides a list of disorders that may be confused with diseases.

Table 14.1.1 Nonpathogenic disorders.

Disorder	Management Option	Recommendation
Air pollution	Variety selection.	Andover and Norland are particularly sensitive varieties.
Hollow heart	Variety selection. Maintain uniform growing conditions.	Varieties differ in severity. Avoid growing oversized tubers. Utilize appropriate plant spacing. Irrigate and fertilize for specific variety requirements.
Internal necrosis	Variety selection. Minimize heat stress.	Varieties differ in susceptibility. Irrigation reduces soil temperatures and increases calcium uptake.
Blackspot	Avoid bruising tubers. Maintain tuber turgor.	Minimize impact events during harvesting, transporting, grading, and handling. Store in high humidity and warm before handling operations.
Secondary tubers	Avoid old seed.	Purchase good quality seed and keep in cold storage.
Greening	Avoid tuber exposure to light.	Keep tubers well covered with soil in the field and store them in the dark after harvest.
Growth cracks	Maintain even soil moisture.	Maintain even soil moisture, especially during rapid tuber growth stage. See Section 9: *Moisture Management*
Knobs	Maintain even soil moisture and fertility.	See Section 9: *Moisture Management*. Maintain uniform soil fertility conditions.

Table 14.1.1 Nonpathogenic disorders.

Disorder	Management Option	Recommendation
Weed damage to tubers (Quack grass and Canada thistle grow through tubers)	Weed management.	Have a program to reduce perennial weeds in fields.
Secondary tubers	Avoid old seed.	Purchase good quality seed and keep in cold storage.

15. Insect Management

Effective insect management relies on accurate identification of pests and beneficial insects, an understanding of their biology and life cycle, knowledge of economically important levels of pest damage, a familiarity with allowable control practices, and their effectiveness, in other words, Integrated Pest Management (IPM).

Regular scouting and accurate pest identification are essential for effective insect management. Thresholds used for conventional production may not be useful for organic systems because of the typically lower percent mortality and shorter residual of control products allowed for organic production. The use of pheromone traps or other monitoring or prediction techniques can provide an early warning for pest problems, and help effectively focus scouting efforts.

The contribution of crop rotation as an insect management strategy is highly dependent on the mobility of the pest. Crop rotation tends to make a greater impact on reducing pest populations if the pest has limited mobility. In cases where insects are highly mobile, leaving a greater distance between past and present plantings is better.

Natural Enemies

Learn to identify naturally occurring beneficial insects, and attract and conserve them in your fields by providing a wide variety of flowering plants in or near the field and avoiding broad-spectrum insecticides. In most cases, a variety of natural enemies are present in the field, each reducing pest populations. The additive effects of multiple species of natural enemies, attacking different host stages, is more likely to make an important contribution to reducing pest populations than an individual natural enemy species operating alone. Natural enemies need a reason to be present in the field, either a substantial pest population, alternative hosts, or a source of pollen or nectar, and may not respond to pest buildup quickly enough to keep populations below damaging levels. Releasing insectary-reared beneficial organisms into the crop early in the pest outbreak may help control some pests but sometimes these biocontrol agents simply leave the area. For more information, see Cornell's Natural Enemies of Vegetable Insect Pests (Reference 94), and Biological Control: A Guide to Natural Enemies in North America (Reference 95).

Regulatory

Organic farms must comply with all regulations regarding pesticide applications. See Section 11 for details. **ALWAYS check with your** organic **farm certifier when planning pesticide applications.**

Efficacy

In general, insecticides allowed for organic production may kill a smaller percentage of the pest population, could have a shorter residual and may be more quickly broken down in the environment than conventional insecticides. Agricultural pesticide manufacturers are not required to submit efficacy data to the EPA as part of the registration process. Listing a pest on the pesticide label does not guarantee the effectiveness of a pesticide. See Section 11.3 for more information.

Cultural control options available for potato insects include (see individual pests for specific recommendations):

- rotation to non-hosts (do not follow next season with potatoes, tomatoes or eggplant)
- hand removal
- propane flaming
- floating row cover
- yellow sticky traps and tape
- trench trap around perimeter
- trap tubers around perimeter
- vacuum - leaf blower operated for suction
- early or late planted trap rows of potatoes
- remove solanaceous weeds from areas bordering potato fields
- straw mulch

When conditions do warrant an insecticide application, proper choice of materials, proper timing, and excellent spray coverage are essential. Thresholds developed using conventional pesticides are often not useful when using organic approved products, which are often less effective than synthetic pesticides.

Resources:

Resource Guide for Organic Insect and Disease Management (Reference 2)

Natural Enemies of Vegetable Insect Pests (Reference 94)

Biological Control: A Guide to Natural Enemies in North America (Reference 95)

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

CLASS OF COMPOUNDS **Product Name** **(*active ingredient*)**	**COLORADO POTATO BEETLE**	**APHIDS**	**POTATO LEAF-HOPPER**	**FLEA BEETLES**	**CUTWORMS**	**EUROPEAN CORN BORER**	**WIREWORMS**	**SYMPHYLAN**	**SPIDER MITES**	**SLUGS & SNAILS**
MICROBIAL										
Biobit (*Bacillus thuringiensis subsp. kurstaki*, str. ABTS-351)					A, B					
Deliver (*Bacillus thuringiensis kurstaki*)					A, B	X				
Dipel DF (*Bacillus thuringiensis*)					A, B					
Entrust (*spinosad*)	X					X				
Entrust SC (*spinosad*)	X					X				
Grandevo (*Chromobacterium subtsugae str. PRAA4-1*)		X	X			X				
Javelin WG (*Bacillus thuringiensis kurstaki*)					B	X				
PFR-97 20% WDG (*Isaria fumosorosea)*		X			X	X	X	X	X	
Seduce Insect Bait (*spinosad*)					X					
Xen Tari (*Bacillus thuringiensis*)					X					
BOTANICAL										
Aza-Direct (*azadirachtin*)	X	X	X	X	A,B	X	X		X	
AzaGuard (*azadirachtin*)	X	X	X	X	A, B	X	X		X	
AzaMax (*azadirachtin*)	X	X	X	X	A, B	X	X		X	
AzaSol (*azadirachtin*)	X	X		X	A, B	X	X			
Azatrol EC (*azadirachtin*)	X	X	X	X	A,B				X	
Azera (*azadirachtin and pyrethrins*)	X	X	X	X	X	X	X	X	X	
BioLink (*garlic juice*)	X	X	X	X	A, B	X	X		X	X
BioLink Insect & Bird Repellant (*garlic juice*)	X	X	X	X	A, B	X			X	X
Ecozin PLUS 1.2% ME (*azadirachtin*)	X	X	X	X	B	X				
Envirepel 20 *(garlic juice)*	X		X	X				X	X	X
Garlic Barrier (*garlic juice*)	X		X	X				X	X	X
Molt-X *(azadirachtin)*	X	X	X	X	A,B	X				
Neemix 4.5 (*azadirachtin*)	X	X	X	X	X					
Pyganic Crop Protection EC 1.4 (*pyrethrins*)	X	X	X	X	A,B	X		X	X	
PyGanic Crop Protection EC 5.0 (*pyrethrins*)	X	X	X	X	A,B	X			X	
Safer Brand #567 (*pyrethrin & soap*)	X	X	X	X	B	X			X	
Trilogy (*neem oil*)		X							X	
OIL										
BioRepel *(garlic oil)*		X	X							
Cedar Gard *(cedar oil)*	X		X	X	A,B	X				
Ecotec *(rosemary and peppermint oil)*		X	X						X	
Ecotec – G *(clove, cinnamon and thyme oils)*							X	X		
GC-Mite *(cottonseed, clove, and garlic oil)*		X							X	
Cinnerate *(cinnamon oil)*									X	
Glacial Spray Fluid (*mineral oil*)	X	X	X	X					X	
GrasRoots (*cinnamon oil*)		X							X	
Oleotrol-I (*soybean oil*)		X							X	

CLASS OF COMPOUNDS Product Name (*active ingredient*)	COLORADO POTATO BEETLE	APHIDS	POTATO LEAF-HOPPER	FLEA BEETLES	CUTWORMS	EUROPEAN CORN BORER	WIREWORMS	SYMPHYLAN	SPIDER MITES	SLUGS & SNAILS
Organic JMS Stylet-Oil (*paraffinic oil*)			X						X	
Organocide 3-in-1 *(sesame oil)*		X							X	
PureSpray Green *(petroleum oil)*	X	X	X	X	A,B	X			X	
SuffOil-X (*petroleum oil*)		X							X	
TriTek *(petroleum oil)*		X							X	
IRON PHOSPHATE										
Bug-N-Sluggo® Insect, Slug and Snail Bait *(iron phosphate and spinosad)*					X					X
Sluggo-AG (*iron phosphate)*										X
Sluggo Slug & Snail Bait (*iron phosphate*)										X
SOAP										
DES-X (insecticidal soap)		X							X	
M-Pede (*potassium salts of fatty acids*)		X	X						X	
SULFUR										
Micro Sulf *(sulfur)*									X	
Microthiol Disperss *(sulfur)*									X	
Thiolux *(sulfur)*									X	
OTHER										
Nuke Em *(citric acid)*		X							X	
Sil-Matrix (*potassium silicate*)		X							X	
Surround WP (*kaolin*)			X	X						

[1] Sulfur can be phytotoxic at temperatures above 90º therefore read and follow the label carefully. A= for subterranean and/or surface cutworm, B= for climbing cutworm

Active ingredient meets EPA criteria for acute toxicity to bees

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

Time for concern: Late April through vine-kill

Key characteristics: The adults have alternate black and yellowish orange stripes that run lengthwise on the wing covers, five of each color on each wing. The beetles are 3/8 inch long by 1/4 inch wide and convex in shape. The eggs are yellowish orange and deposited in masses that contain between 20 and 40 eggs. Larvae are small, humpbacked, and red with two rows of black spots on each side of their body. See Cornell fact sheet (Reference 96), life cycle photos(Reference 97) and an older but informative fact sheet (Reference 98). Adults and larvae feed on leaves and stems. Adults hibernate in the ground in and near potato fields, emerge in the spring and disperse to solanaceous host plants where they feed and give rise to 1 or 2 larval generations in upstate New York.(Reference 93).

Risk assessment: Colorado potato beetle is a serious pest of potatoes. If left uncontrolled, it can devastate yields with reductions up to 90%. Most varieties can tolerate moderate defoliation (up to 30%) in the early season without affecting yield. Next to leafhopper, this is the most serious insect pest of potatoes.

Management Option	Recommendation for Colorado Potato Beetle
Scouting/thresholds	Take a representative sample of the field weekly. Sample five vines at five sites. For fields of an acre or less, this constitutes your entire sample. Compute means and compare to thresholds below. For larger fields, count the number of adults, small larvae (less than 1/4 inch), and egg masses. Count egg masses with less than ten eggs as half an egg mass. If the number of CPB in a particular life stage falls within the range given below or if the field is >30 acres, sample 25 more vines. The basic sample unit should be a plant "hill" until plants are 12 inches in height and a single main stem the remainder of the season.

Management Option	Recommendation for Colorado Potato Beetle

Life stage	Number of CPB counted on 25 vines		
	LOW	INTERMEDIATE	HIGH
	Stop	Sample 25	Stop
	Compute Mean	more vines	Compute Mean
Small larvae	<52	53-199	>200
Large larvae	<22	23-67	>68
Adults	<7	8-22	>23

If mean counts are lower than values given above, sample again next week. If any counts are higher than the values given above, sample 25 more plants and compute the means. Don't sample more than 50 vines per field. Report mean numbers of adults and larvae per 50 vines. If mean values exceed threshold values, apply insecticide. If thresholds are not reached but hot spots are found, flag hot spots and apply insecticide.

	Thresholds/50 vines
Egg masses	4 with at least 25% of the earliest deposited egg masses hatched or in the process of hatching
Small larvae	76
Large larvae	31

Resistance management

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. Entrust is very vulnerable to resistance development because it is so effective that it is tempting to overuse it. Do not rely exclusively on Entrust for CPB control. Employ all possible cultural practices to minimize the number of insecticide sprays applied. Rotate with other insecticides.

Before July 15

Overwintered Adults (trap cropping and then flaming or vacuuming; floating row cover; trench trapping)

1st Larval Generation (Focus your Entrust use on this important stage)

After July 15

Summer Adults (try to minimize the number of larvae surviving to adulthood and avoid treating this stage. Remember that potatoes can tolerate 10-15% damage without yield loss)

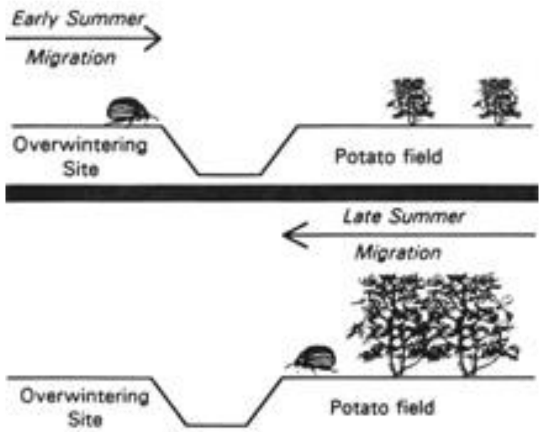
2nd Larval Generation (Do not apply Entrust to both generations of larvae; an azadirachtin product or mixture of azadirachtin and pyrethrin may be a useful alternative.

To minimize selection for resistance, only use insecticides when needed; use the minimum dosage necessary to provide control; rotate insecticides of different chemical classes and modes of action; create refuges untreated by insecticides where susceptible populations can survive to mate with resistant individuals and dilute the frequency of resistant genes in pest populations.

Natural enemies

Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Biological Control: A Guide to Natural Enemies in North America (Reference 95) to identify natural enemies.

Management Option	Recommendation for Colorado Potato Beetle
Resistant varieties	Elba, Prince Hairy and King Harry are resistant to CPB's. Varieties that mature in 75-88 days and thus avoid peak CPB infestations include: Caribe, Norland, Redsen, Sunrise, Superior and Yukon Gold.
Crop rotation	One year rotation to non-host crops such as small grains or corn can result in greater than 90 percent reduction of early-season adult infestation. Other non-hosts to add in rotation include crucifers and forage crops. Avoid tomatoes, eggplants, and other species belonging to the solanaceae family. Rotation is most effective when large blocks are rotated on a farm or coordinated among adjacent farms. On diversified vegetable farms, rotate tomatoes, potatoes, and eggplant as a block. Minimize the presence of volunteer potatoes in rotational crops by avoiding fall plowing, leaving the tubers on the surface to freeze. Plant slow-emerging or late-season varieties to fields that did not have potatoes the previous year.
Site selection	Avoid planting potatoes near fields where late-season cultivars with high CPB populations were grown the previous year.
Planting	Plants that are strong and well established before CPB attack will better withstand feeding damage. Planting as early as possible and covering as shallowly as possible will give plants a head start. Growers in the most northern regions of New York avoid CPB by planting mid to late June; yields are somewhat reduced but they find the trade off worthwhile.
Flaming	Adult CPB's overwinter in hedgerows and wooded areas adjacent to potato fields. Flaming is most effective when used around the borders (the outside eight to 16 rows) of the field. However, in the case of widespread colonization by adults, flaming is more successful when used throughout the field. The most effective time to use a propane flamer is from plant emergence until the plants reach six inches in height. Best control is achieved on warm, sunny days with little wind when adults are actively feeding in the upper foliage. Flaming is ineffective when done in the early morning, late evening, or on cool, cloudy days when adults are in the lower portion of the plant or near the soil level. Burners should be operated eight to ten inches above the soil at four to six miles per hour. Plant injury from flaming is minimal and does not reduce yields. See Reference 99 for videotapes that detail flame weeding.
Vacuum/leaf blower	Adult beetles can be removed from trap crop using a retail leaf blower (many brands can be operated in reverse as vacuums). This practice may not be advisable when pathogens like powdery mildew and gray mold are present and might be spread by the vacuum.
Trap strips & trap tubers	Early season: Plant strips of a fast-emerging early variety along the edges of the field as early as weather and soil conditions will allow. Cover seed shallowly to promote rapid emergence. The trap crop should emerge before the main crop so trap plants are larger and able to withstand feeding and so sufficient foliage remains to keep the trap crop attractive. A flamer or vacuum can be used to remove the adults on the trap crop. Late season: Plant strips of late emerging, late maturing cultivar such as Elba or Allegany. Foliage of these varieties will remain green and attractive to dispersing adults much longer than those of shorter season cultivars. A flamer or vacuum can be used to remove adults on the trap crop. Cut tubers placed along the perimeter of a potato field prior to sprout emergence can also be effective in arresting and congregating adult potato beetles for control by flaming.

Management Option	Recommendation for Colorado Potato Beetle
Trench trap	 *Adapted from* Boiteau, G. et al. 1993. Plastic Trench Barrier for Protection of Potatoes From Walking Adult Colorado Potato Beetles. pp. 14-16. Entomology Program Research Summary, Fredericton Research Station. Agriculture Canada. Trench traps effectively control adult beetles when hibernation areas are known. Install plastic-lined trench traps next to hibernation sites or between adjacent fields at least one week before adults emerge. Adults dispersing by walking (50-75% of the overwintered population) are trapped in the trench and die of dehydration. Trenches should be one to two feet deep and six to 24 inches wide at the top. They can be U or V shaped with sidewalls sloping at angles between 65 and 90 degrees. Level the crown at the top of the trench and line the trench with mulching plastic. For a more detailed description, see video (Reference 99). Summer adults may likewise be trapped as they disperse from the potato fields to their overwintering sites.
Harvest	Scheduling vine killing/harvest as soon as the crop is mature eliminates the food source for the Colorado potato beetle and reduces the number and health of overwintering adults.
Postharvest	Flooding (which occurs naturally on many muck fields) can reduce overwintering populations.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.1 Pesticides for Management of Colorado Potato Beetle

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Azadirachtin based products effective in 3/3 trials. Consult label for application timing. Best control is achieved at the upper end of the use range.Does not provide immediate mortality. Intoxicated nymphs and larvae die at their next molt. Foliage contact and coverage extremely important.
AzaGuard (azadirachtin)	8-16 fl oz/acre	0	4	1	See comment for Aza-Direct.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	1	See comment for Aza-Direct.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for Aza-Direct.

Table 15.1 Pesticides for Management of Colorado Potato Beetle

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Azatrol-EC (azadirachtin)	0.11-0.22 fl oz/ 1000 sq ft	0	4	1	See comment for Aza-Direct.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	1	See comment for Aza-Direct.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	3	25(b) pesticide. Plant and petroleum oil based products effective against beetles in 0/1 trial.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	3	25(b) pesticide. See comment for BioLink.
Cedar Gard (cedar oil)	1 qt/acre	-	-	3	25(b) pesticide. See comment for BioLink.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	See comment for Aza-Direct.
Entrust (spinosad)	1-2 oz/acre	7	4	1	Spinosad based products effective in 14/14 trials. Very good control of all larval stages but no control of adults or eggs.
Entrust SC (spinosad)	3-10 fl oz/acre	7	4	?	See comment for Entrust.
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	3	25(b) pesticide. See comment for BioLink.
Garlic Barrier AG (garlic juice)	1 gal/ 99 gal water	-	-	3	25(b) pesticide. See comment for BioLink.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	3	See comment for BioLink. See label for specific application volumes. Labeled for beetle larvae.
Molt-X (azadirachtin)	8 oz/acre	0	4	1	See comment for Aza-Direct. For Molt-X, use in combination with anorganic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemix 4.5 (azadirachtin)	7-16 fl oz/acre	0	4	1	See comment for Aza-Direct.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	3	See comment for BioLink. Labeled for beetle larvae.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	1	Pyrethrum based products effective in 3/3 trials.Target first instars. Foliage contact and coverage extremely important; UV sensitive, spray late in the day.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	1	See comment for PyGanic EC 1.4 II.
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	Until Dry	12	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.2 Aphids, primarily the green peach aphid, *Myzus persicae*; Potato Aphid, *Macrosiphum euphorbiae*; Melon Aphid, *Aphis gossypii*; Buckthorn Aphid, *Aphidula rhamni*; and Foxglove Aphid, *Aulacorthum solani*

Time for concern: June through vine-kill

Key characteristics: Adults of the potato infesting aphid species are approximately 1/25 to 2/25 inch in length and vary in color from yellow to black. They may be winged or wingless. In the fall, winged aphids are produced and mate. The eggs are black and less than 1/50 inch in length. See Cornell aphid fact sheet (Reference 101), melon aphid fact sheet (Reference 102) and aphid photos (Reference 103).

Relative Risk: Aphids are rarely a problem on organic farms due to the higher numbers of parasites and predators, but they can transmit viruses, which will affect yield of potatoes and other crops susceptible to viruses. Virus infection is more serious for growers who save their own seed.

Management Option	Recommendation for Aphids
Scouting/thresholds	Early detection of migrant aphids is extremely important to **seed growers** who must minimize spread of potato leafroll virus and other aphid-vectored virus diseases in their fields. Yellow sticky traps and tape are useful in determining initial arrival of winged aphids and their seasonal presence/absence. Plant damage from feeding by aphids is often subtle and seldom reflected, at least in the early stages, by obvious changes in plant growth, growth form, or foliage color. Large populations may be detected by the appearance of cast skins, sooty mold, or shiny honeydew accumulations on lower foliage and the soil. Put up either yellow sticky traps or water-pan traps. Traps should be examined twice a week and the number of winged aphids recorded and removed. A total catch of ten aphids per trap over a seven day period is an alert to the possible need for application of an insecticide. When the number of aphids per trap increases, examine one fully expanded leaf from each of five different plants in different rows at each of ten sites per field. Count all of the aphids. Apply insecticide when the following action threshold is reached. <u>PLANT GROWTH STAGE</u> — <u>ACTION THRESHOLD</u> Before tuber initiation — 100 aphids/50 leaves Tuber initiation[1] to 2 weeks before vine kill — 200 aphids/50 leaves Within 2 weeks of vine kill — 500 aphids/50 leaves In addition, seed potato growers may consider applying stylet oil to hinder virus transmission by aphids (see Section 12.17: Virus Diseases).
Site selection	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.
Resistant varieties	Although all currently available potato cultivars are susceptible to infection by the potato leaf roll virus (PLRV), many cultivars are resistant to the manifestation of virus infection (net necrosis) in tubers.
Seed selection/treatment	Plant phytosanitary certified seed.
Mulches	Aphids are repelled by ultra violet light. Reflective mulches have been effective in limiting virus transmission by winged migrant aphids.
Natural enemies	Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) to identify natural enemies.
Yellow sticky traps and tape	Traps should be located away from tree lines and tall weeds where they might be obscured and should be at least 12 inches above the plant canopy. Mount traps vertically along the edges of the field by stapling to a wooden stake.
Water-pan traps	Traps should be located away from tree lines and tall weeds where they might be obscured and should be at least 12 inches above the plant canopy. Any watertight container holding a minimum of one gallon of water with a minimum diameter of twelve inches can be used. If metal containers are used,

Management Option	Recommendation for Aphids
	they must be painted a deep yellow. The trap must be equipped with an overflow for rainwater by cutting a circular hole one inch in diameter in the side of the pan about two inches below the rim. A small piece of window screen should be cemented over the hole to retain aphids when rainwater raises the level of water in the pan. Fill the pan with several inches of water, several drops of liquid dishwashing detergent, and one teaspoon of disinfectant (See Section 10.3: *Storage Facility Sanitation*)
Floating row covers	Don't use floating row covers on areas where emerging insects from last year will be trapped.
Vacuum/leaf blower	Aphids can be vacuumed from leaves using a leaf blower operated for suction. This practice may not be advisable when pathogens like powdery mildew and gray mold are present and might be spread by the vacuum.
Harvest	Vine kill and harvest the crop as early as possible to minimize vulnerability to late-season aphid colonization and virus infection.
Sanitation	Maintain effective management of weeds in and on the margins of fields. Eliminate volunteer plants and rogue diseased plants.
Note(s)	Aphid populations may decline rapidly during periods of heavy rainfall. Insecticides applied for leafhoppers may also suppress aphids.

[1]Tuber initiation and bulking coincides with the period following flowering for many cultivars

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.2 Pesticides for Management of Aphids

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Does not provide immediate mortality. Intoxicated nymphs and larvae die at their next molt. Foliage contact and coverage extremely important. Azadirachtin based products effective on green peach aphid in 4/7 studies and on other aphids in 3/4 studies.
AzaGuard (azadirachtin)	10-16 fl.oz./acre	0	4	1	See comment for Aza-Direct. Use with OMRI approved spray oil
AzaMax (azadirachtin)	1.33 fl oz/ 1000 sq ft	0	4	1	See comment for Aza-Direct.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for Aza-Direct.
Azatrol-EC (azadirachtin)	0.11-0.22 fl oz/1000 ft^2	0	4	1	See comment for Aza-Direct.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	1	See comment for Aza-Direct.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.

Table 15.2 Pesticides for Management of Aphids					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
BioRepel (garlic oil)	1 part BioRepel with 100 parts water	-	-	2	25(b) pesticide. Oil based products effective in 2/5 trials.
DES-X (insecticidal soap)	2% solution	1/2	12	?	Soap based products effective in 0/9 trials on green peach aphid but effective in 6/8 trials on other aphids.
Ecotec (rosemary oil, peppermint oil)	1-4 pts/acre	-	-	2	25(b) pesticide. See comment for BioRepel.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	See comment for Aza-Direct.
GC-Mite (garlic oil, clove oil, cottonseed oil)	1 gal/100 gal water	-	-	2	25(b) pesticide. See comment for Aza-Direct.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	2	See label for specific application volumes. See comment for BioRepel.
Grandevo (*Chromobacterium subtsugae* str. PRAA4-1)	2-3 lb/acre	0	4	?	
GrasRoots (cinnamon oil)	1 part GrasRoots to 9 parts water	-	-	?	25(b) pesticide.
Molt-X (azadirachtin)	10 oz/acre	0	4	1	See comment for Aza-Direct. For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.
M-Pede (insecticidal soap)	1-2% volume to volume	0	12	2	Soap based products effective in 0/9 trials on green peach aphid but effective in 6/8 trials on other aphids. Apply in sufficient volume to wet both upper and lower leaf surfaces. Foliage contact and coverage extremely important. For aphid control, M-Pede must be mixed with another labeled insecticide.
Neemix 4.5 (azadirachtin)	5-7 fl oz/acre	0	4	1	See comment for Aza-Direct.
Nuke Em Natural Insecticide and Fungicide (citric acid)	1 fl oz/31 oz water to 2 fl oz/30 fl oz water	-	-	?	25(b) pesticide.
Oleotrol-I Bio-Insecticide Concentrate (soybean oil)	1 part Oleotrol-I with 300 parts water	-	-	2	25(b) pesticide. Oil based products effective in 2/5 trials.
Organocide (sesame oil)	1-2 gal/100 gal water	-	-	2	25(b) pesticide. See comment for Oleotrol-I.
PFR-97 20% WDG (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	Repeat at 3-10 day intervals as needed to maintain control.

Table 15.2 Pesticides for Management of Aphids

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	2	Oil based products effective in 2/5 trials.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl.oz./acre	until dry	12	2	Pyrethrum based products effective in 1/3 trials.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl.oz./acre	0	12	2	Foliage contact and coverage extremely important; UV sensitive, spray late in the day. Pyrethrum based products effective in 1/3 trials.
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	
Sil-Matrix (potassium silicate)	0.5-1% solution	0	4	?	
SuffOil-X (aliphatic petroleum solvent)	1-2 pt/100 gal water	up to day	4	2	Oil based products effective in 2/5 trials. Do not mix with sulfur products.
Trilogy (neem oil)	1-2% solution in 25-100 gal of water/acre	Up to day	4	2	Maximum labeled rate of 2 gallons/acre/application. Oil based products effective in 2/5 trials. Bee Hazard. This product is toxic to bees exposed to direct contact.
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	2	Oil based products effective in 2/5 trials.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.3 Potato Leafhopper, *Empoasca fabae*

Time for concern: Early June through August

Key characteristics: Adult is wedge-shaped, iridescent green in color, and 1/8 inch long. The body is widest at the head. Eggs are laid singly on the underside of leaves. Both adults and nymphs are very active, running forward, backward, or sideways. The potato leafhopper (PLH) feeds on plant sap in leaflets, petioles and stems causing a physiological response called "hopperburn." PLH damage can stunt potato plants, and kill seedlings. The first sign of hopperburn is whitening of the veins. These areas become flaccid and yellow in color, then desiccate, turn brown, and die. Leaf curling may occur. The entire process takes four to five days. See Alternative Management Techniques video (Reference 105), fact sheet (Reference 106) and life cycle and damage (Reference 107).

Relative Risk: Leafhoppers are a threat every growing season. Short of late blight, leafhoppers are the most serious pest of potato. Yield reductions on susceptible varieties can be up to 50% to 90% depending on how early in the season the damage occurs. Leafhoppers normally move into New York on air currents from the south and west resulting in more serious problems in Western NY.

Management Option	Recommendation for Potato Leafhopper
Scouting/thresholds	Spring migrations of adult leafhoppers pose a risk over large areas and it is difficult to predict potential for damage without monitoring the pest population. Check for the presence of adult PLH's by using a sweep net or by placing yellow sticky traps near the field edges. If yellow sticky traps indicate the presence of adult leafhoppers in the area, sweep sampling should be initiated. At each of ten sites, make ten sweeps with the sweep net. Each sweep consists of a single 180 degree pass across the canopy, perpendicular to the row. The net should brush the top of the canopy but not injure the plants. Empty the net and count the number of adults. Nymphs are best sampled by visual examination of the undersides of leaves on the lower half of the plant. Threshold: treat when more than one adult is found per sweep or more than 15 nymphs are found on 50 leaves. Scout weekly.
Resistant varieties	Elba, and King Harry are resistant to the potato leafhopper. 'Green Mountain', some russets, 'Snowden', 'Ontario', and 'Katahdin are more tolerant. Early maturing cultivars like Superior and Norland, are unusually susceptible to yield reduction caused by leafhopper feeding.
Natural enemies	Although a variety of natural enemies of potato leafhopper have been reported, their impact on infestations is not well known. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) to identify natural enemies.
Cultural	High pressure water will dislodge nymphs. Increase pressure of spray mix to increase effectiveness of treatment.
Floating row cover	Row covers can be used to exclude leafhoppers early in the season. Don't use floating row covers on areas where overwintering insect pests such as adult CPB and flea beetles from last year will be trapped.
Sticky traps and tape	Use yellow sticky traps placed near field edges to monitor leafhopper migration into field. Traps should be located away from tree lines and tall weeds where they might be obscured and should be at least 12 inches above the plant canopy. Mount traps vertically along the edges of the field by stapling to a wooden stake.
Vacuum/leaf blower	Leafhoppers can be vacuumed from leaves using a leaf blower set in reverse. This practice may not be advisable when pathogens like powdery mildew and gray mold are present and might be spread by the vacuum.
Site selection	Avoid planting fields immediately downwind of any barrier. Hedgerows, wood lots, or hilly terrain reduce wind velocity and increase the number of dispersing leafhoppers falling into fields. Potatoes grown near large acreages of alfalfa are particularly vulnerable because of the dispersal of adults from alfalfa following cutting.
Sanitation	If area around the potato field is mowed, mow frequently, or leafhopper populations will build up in weeds and mowing will send leafhoppers into potatoes.
Notes	Nymphs are very susceptible to starvation when dislodged from plants in spring and summer rainstorms.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.3 Pesticides for Management of Potato Leafhopper

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Does not provide immediate mortality. Intoxicated nymphs and larvae die at their next molt. Foliage contact and coverage extremely important. Azadirachtin based products effective in 1 recent trial.
AzaGuard (azadirachtin)	10-16 fl oz/acre	0	4	1	See comment for Aza-Direct.
AzaMax (azadirachtin)	1.33 fl oz/ 1000 ft^2	0	4	1	See comment for Aza-Direct.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/ 1000 ft^2	0	4	1	See comment for Aza-Direct.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	1	See comment for Aza-Direct.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.
BioRepel (garlic oil)	1 part BioRepel with 100 parts water	-	-	2	25(b) pesticide.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
Ecotec (rosemary oil, peppermint oil)	1-4 pts/acre	-	-	?	25(b) pesticide.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	See comment for Aza-Direct.
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	?	25(b) pesticide.
Garlic Barrier AG (garlic juice)	1 gal/ 99 gal water	-	-	?	25(b) pesticide.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	?	See label for specific application volumes.
Grandevo (*Chromobacterium subtsugae* str. PRAA4-1)	2-3 lb/acre	0	4	?	
Organic JMS Stylet-Oil (parrafinic oil)	3-6 qt/100 gal water	0	4	?	Do not apply within 10-14 days of sulfur applications.
Molt-X (azadirachtin)	10 oz/acre	0	4	1	See comment for Aza-Direct. For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.
M-Pede (insecticidal soap)	1-2% volume to volume	0	12	3	Soap products effective in 0/1 trial.
Neemix 4.5 (azadirachtin)	7-16 fl oz/acre	0	4	1	See comment for Aza-Direct.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	?	

Table 15.3 Pesticides for Management of Potato Leafhopper					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	1	Pyrethrum based products effective in 1/1 trial.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	1	Foliage contact and coverage extremely important; UV sensitive, spray late in the day. Pyrethrum based products effective in 1/1 trial. Reinfestation is likely so repeated applications at tight intervals might be necessary.
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	
Surround WP (kaolin clay)	25-50 lb/acre	up to day	4	3	Effective in 0/3 trials. Suppression only. Apply every 7 -10 days, starting prior to infestation.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.4 Flea Beetles, *Epitrix cucumeris*, *Systena frontalis* & other species

Time for concern: May through August

Key characteristics: Shiny, black beetle, about 1/16 inch long, that jumps when disturbed and chews tiny holes in foliage. Larvae are slender white worms that usually feed on roots; second generation larvae sometimes feed on tubers producing pits and roughness. See Cornell fact sheet (Reference 108) and life cycle and damage (Reference 109).

Relative risk: Foliage feeding by adult flea beetles rarely causes yield reduction but high larval populations in the soil can lead to serious tuber defects.

Management Option	Recommendation for Flea Beetles
Scouting/thresholds	Use sticky traps to monitor for first seasonal appearance (or presence/absence) of adult flea beetles. Check for the presence of adult flea beetles by using a sweep net or by examining foliage. Begin treatment at threshold of 2 adults per sweep and/or 15 feeding holes per terminal leaf.
Resistant varieties	King Harry is resistant to flea beetles.
Planting	Plants that are strong and well established before flea beetles attack will better withstand feeding damage. Planting as early as possible and covering as shallowly as possible will give plants a head start.
Natural enemies	Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) to identify natural enemies.
Floating row cover	Protect young plants from flea beetle damage with floating row covers. Remove row covers before temperatures get very hot in mid-summer.
Yellow sticky traps & tape	Sticky traps and tape may be useful in providing some control of adults.
Vacuum/leaf blower	Flea beetles can be vacuumed from leaves using a leaf blower set operated for suction. This practice may not be advisable when pathogens like powdery mildew and gray mold are present and might be spread by the vacuum.
Crop rotation, Site selection, Postharvest, and Sanitation	Not effective.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.4 Pesticides for Management of Flea Beetles

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	2	Does not provide immediate mortality. Intoxicated nymphs and larvae die at their next molt. Foliage contact and coverage extremely important.Azadirachtin based products effective in 1/3 trials.
AzaGuard (azadirachtin)	8-16 fl oz/acre	0	4	2	See comment for Aza-Direct. Use with OMRI approved spray oil.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	2	See comment for Aza-Direct
AzaSol (azadirachtin)	6 oz/acre	-	4	2	See comment for Aza-Direct
Azatrol-EC (azadirachtin)	0.11-0.22 fl oz/ 1000 ft^2	0	4	2	See comment for Aza-Direct
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	2	See comment for Aza-Direct
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Not recommended for subterranean since applied to foliage.
Cedar Gard (cedar oil)	1 qt/acre	-	-	3	25(b) pesticide. Oil products effective in 0/1 trial against beetle species.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	2	See comment for Aza-Direct
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	?	25(b) pesticide.
Garlic Barrier AG (garlic juice)	1 gal/ 99 gal water	-	-	?	25(b) pesticide.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	3	See label for specific application volumes. Labeled for beetle larvae.Oil products effective in 0/1 trial against beetle species.
Molt-X (azadirachtin)	8 oz/acre	0	4	2	See comment for Aza-Direct. For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemix 4.5 (azadirachtin)	7-16 fl oz/acre	0	4	2	See comment for Aza-Direct
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	3	Labeled for beetle larvae.Oil products effective in 0/1 trial against beetle species.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	1	Pyrethrum based products effective in 4/6 trials.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	1	Foliage contact and coverage extremely important; UV sensitive, spray late in the day.Pyrethrum based products effective in 4/6 trials.

Table 15.4 Pesticides for Management of Flea Beetles					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	
Surround WP (kaolin clay)	25-50 lb/acre	up to day	4	3	Surround effective in 0/4 trials. Suppression only. Apply every 7 -10 days, starting prior to infestation.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.5 Subterranean and Surface Cutworms

Time for concern: May through harvest

Key characteristics: Many species of cutworms attack potatoes. The larvae are brown or gray and grow to about 1/5 inch in length. Some species cut the stems at the soil level, while others feed underground. Subterranean cutworms stay underground and feed on potato roots. Surface cutworms feed at the surface and are famous for severing new seedlings at or slightly above ground level. See Cornell's fact sheet(Reference 110) and cutworm life cycle(Reference 112).

Relative Risk: These pests are not a consistent problem in New York potatoes.

Management Option	Recommendation for Subterranean and Surface Cutworms
Scouting/thresholds	Thresholds have not been established for organic production.
Resistant varieties	No resistant varieties are available.
Site selection	Weedy fields are at greater risk of attracting moths for egg laying, which can lead to a build up of larvae.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.5 Pesticides for Management of Subterranean and and Surface Cutworms					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	?	Foliar spray or soil drench.
AzaGuard (azadirachtin)	8-16 fl oz/acre	0	4	?	Use with OMRI approved spray oilFoliar spray or soil drench.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	?	Foliar spray or soil drench.
AzaSol (azadirachtin)	6 oz/acre	-	4	?	Foliar spray or soil drench.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/1000 ft^2	0	4	?	
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	?	Foliar spray or soil drench.

Table 15.5 Pesticides for Management of Subterranean and and Surface Cutworms

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Biobit HP (*Bacillus thuringinensis* subsp. Kurstaki)	0.5-1 lb/acre	0	4	?	Must be eaten by larvae. Not recommended for subterranean cutworm since applied to foliage.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.Not recommended for subterranean since applied to foliage.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. See comment for BioLink.
Bug-N-Sluggo (spinosad, iron phosphate)	20-44 lb/acre Soil treatment	7	4	?	
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
Deliver (*Bacillus thuringinensis* subsp. Kurstaki)	0.25-1.5 lb/acre	0	4	?	Must be eaten by larvae. Not recommended for subterranean cutworm since applied to foliage.
Dipel DF (*Bacillus thuringinensis* subsp. Kurstaki)	0.5-2 lb/acre	0	4	?	See comment for Deliver.
Molt-X (azadirachtin)	8 oz/acre	0	4	?	For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves. Foliar spray or soil drench.
Neemix 4.5 (azadirachtin)	4-10 fl oz/acre	0	4	?	See comment for Deliver.
PFR-97 20% WDG (*Isaria fumosorosea* Apopka str. 97)	1-2 lb/acre	-	4	?	Labeled for caterpillars.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	?	Labeled for caterpillars.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl.oz./acre	until dry	12	?	Labeled for caterpillars. See comment for Deliver.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl.oz./acre	0	12	?	Labeled for caterpillars. See comment for Deliver.
Seduce Insect Bait (spinosad)	20-44 lb/acre broadcast	7	4	?	
XenTari (*Bacillus thuringiensis*, var. aizawai)	0.5-1.5 lb/acre	0	4	?	Must be eaten by larvae. See comment for Deliver.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.6 Climbing Cutworm, primarily the variegated cutworm, *Peridroma margaritosa*

Time for concern: June through August

Key characteristics: The adult is a brown moth that lays eggs in masses of 60 or more. Larvae are nocturnal, seldom seen during the day, and curl into a C when disturbed. Mature larvae, 1 1/4 to 1 3/4 inches in length, may appear "greasy." Larvae feed on aerial parts of the potato plant, producing defoliation similar in appearance to that caused by the Colorado potato beetle except that most feeding occurs on the lower half of the plant. Tubers are seldom damaged by direct feeding. Yields can be reduced if substantial defoliation occurs during tuber initiation and bulking. See Reference 111, Cornell fact sheet (Reference 110) and life cycle (Reference 112).

Risk Assessment: This is an occasional problem in potatoes.

Management Option	Recommendation for Climbing Cutworm
Scouting/thresholds	Examine the foliage in the evening for the presence of larvae and signs of feeding. Also examine wet, low- lying areas of the field for the presence of larvae. Examine 25 randomly chosen plants. Threshold: when the population reaches an average of three larvae per stem or if post-bloom defoliation exceeds 15 percent of the vine.
Resistant varieties	No resistant varieties are available.
Natural enemies	Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) for identification of natural enemies.
Insecticide use	Larvae are present on the foliage only during the evening, and insecticides will be most effective if applied during this period or near dusk. Thorough coverage of the foliage and soil surface is essential for good management. This may require the use of application equipment delivering at least 50 GPA at pressures of 60 psi or more.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.6 Pesticides for Management of Climbing Cutworms

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	?	Does not provide immediate mortality. Intoxicated nymphs and larvae die at their next molt. Foliage contact and coverage extremely important. Foliar spray or soil drench.
AzaGuard (azadirachtin)	8-16 fl oz/acre	0	4	?	Use with OMRI approved spray oilFoliar spray or soil drench.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	?	Foliar spray or soil drench.
AzaSol (azadirachtin)	6 oz/acre	-	4	?	Foliar spray or soil drench.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/1000 ft^2	0	4	?	
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	?	Foliar spray or soil drench.
Biobit HP (*Bacillus thuringinensis* subsp. kurstaki)	0.5-1 lb/acre	0	4	?	
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.
Bug-N-Sluggo (spinosad, iron phosphate)	20-44 lb/acre soil treatment	7	4	?	
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
Deliver (*Bacillus thuringinensis* subsp. kurstaki)	0.25-1.5 lb/acre	0	4	?	

Table 15.6 Pesticides for Management of Climbing Cutworms

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Dipel DF (*Bacillus thuringinensis* subsp. kurstaki)	0.5-2 lb/acre	0	4	?	Residue on foliage must be eaten by larvae. Does not provide immediate mortality.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	?	Foliar spray or soil drench.
Javelin WG (*Bacillus thuringinensis* subsp. kurstaki)	0.12-1.5 lb/acre	0	4	?	
Molt-X (azadirachtin)	8 oz/acre	0	4	?	For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.Foliar spray or soil drench.
PFR-97 20% WDG (*Isaria fumosorosea* Apopka str. 97)	1-2 lb/acre	-	4	?	Labeled for caterpillars.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	?	Labeled for caterpillars.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	?	Labeled for caterpillars.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	?	Labeled for caterpillars.
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	
Seduce Insect Bait (spinosad)	20-44 lb/acre broadcast	7	4	?	
XenTari (*Bacillus thuringiensis* var. aizawai)	0.5-1.5 lb/acre	0	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.7 European Corn Borer (ECB), *Ostrinia nubilalis*

Time of concern: June and July

Key characteristics: Eggs are white and laid in scale-like masses on the underside of leaves. The larvae are gray with rows of brown spots and a dark brown head capsule. Larvae are 3/4 inch long when fully developed. The adult is a yellowish/reddish brown moth, about one inch in length. See Reference 113A to accurately determine if moths in the field are actually ECB moths. See Cornell fact sheet (Reference 113), life cycle (Reference 114) and management bulletin (Reference 115).

Relative risk: European corn borer is a sporadic problem usually affecting potatoes grown near infested corn fields. Isolated potato farms rarely see this insect even though it is a fairly strong flyer. Economically, this is normally a minor pest unless there is black leg on the seed or in wet weather on some varieties. In the absence of blackleg inoculum, economic damage from the corn borer alone is insignificant except at infestation levels exceeding 35% infested stems.

Management Option	Recommendation for European Corn Borer
Scouting/thresholds	The optimum time for application of an insecticide coincides with hatching of egg masses and is best determined by the detection of peak flight periods. Monitor peak flight periods using blacklight and pheromone traps or by caging infested corn stalks from a nearby field in a screened enclosure. Apply insecticide on a schedule when moths are in the area and flying to provide best control. It is also advisable to sample the grassy areas bordering fields since the adults frequent these areas during daylight hours and may be more readily found in these areas than within cropped areas. Sampling for egg masses is impractical in potatoes. Furthermore, monitoring for larvae and for broken or wilted stems serves no useful purpose because control cannot be achieved once larvae have penetrated stems.
Site selection	Avoid planting potatoes in fields that have been rotated to corn. If this is not feasible, cut corn stubble as short as possible and shred stalk material over a wide area to destroy the majority of overwintering larvae.
Resistant varieties	Survival and establishment of larvae vary depending on potato cultivar and field conditions. Larval survival on three popular cultivars follows: > Monona > Superior > Katahdin. Under field conditions, Monona is more susceptible to attack by ECB's and to infection by aerial blackleg than other cultivars.
Natural enemies	Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) to identify natural enemies. Trichogramma ostriniae releases have been found effective. See T. ostriniae to help manage ECB (Reference 116) for more information.
Plowing	Up to 60 percent of overwintering larvae may be killed by moldboard or chisel plowing or disking prior to moth emergence. If corn is included in the rotation, silage corn is less likely to harbor ECB larvae than ear (or seed) corn. With the latter, cut stalks as short as possible following harvest and shred to further reduce overwintering larvae. This tactic is effective when implemented over a large area.
Sanitation	Mow adjacent weeds and grass, where moths take shelter during the day, to force females to move away from potato fields. Remove volunteer corn that may attract ECB moths to the potato field.
Harvest	A simple mechanical device that attaches to the harvester can be used to crush potato stems where larvae overwinter. Initial studies in Canada showed that crushing the stems resulted in a 95% reduction in larval survival. See Canadian Pest Management Centre article (Reference 117)

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.7 Pesticides for Management of European Corn Borer

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	?	Does not provide immediate mortality. Intoxicated larvae die at their next molt. Foliage contact and coverage extremely important. Foliar spray or soil drench.
AzaGuard (azadirachtin)	8-16 fl oz/acre	0	4	?	See comment for Aza-Direct. Use with OMRI approved spray oil.

Table 15.7 Pesticides for Management of European Corn Borer

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
AzaMax (azadirachtin)	1.33 fl oz/ 1000 ft^2	0	4	?	See comment for Aza-Direct.
AzaSol (azadirachtin)	6 oz/acre	-	4	?	See comment for Aza-Direct.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	?	See comment for Aza-Direct.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
Deliver (Bacillus thuringinensis subsp. kurstaki)	0.25-1.5 lb/acre	0	4	3	Bacillus thuringiensis products effective in 0/2 trials.
Dipel DF (Bacillus thuringinensis subsp. kurstaki)	0.5-2 lb/acre	0	4	?	Residue on foliage must be eaten by larvae. Does not provide immediate mortality.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	?	See comment for Aza-Direct.
Entrust (spinosad)	1-2 oz/acre	7	4	1	Spinosad based products effective in 3/4 trials. Need to be applied at or just before egg hatch. Foliage contact and coverage extremely important; short residual activity.
Entrust SC (spinosad)	3-6 fl oz/acre	7	4	1	Spinosad based products effective in 3/4 trials.
Grandevo (Chromobacterium subtsugae str. PRAA4-1)	1-3 lb/acre	0	4	?	
Javelin WG (*Bacillus thuringinensis* subsp. kurstaki)	0.12-1.5 lb/acre	0	4	3	Bacillus thuringiensis products effective in 0/2 trials.
Molt-X (azadirachtin)	8 oz/acre	0	4	?	See comment for Aza-Direct. For Molt-X, use in combination with an organic 0.25-1% nonphytotoxic crop oil in sufficient water to cover undersides of leaves.
PFR-97 20% WDG (*Isaria fumosorose*a Apopka str. 97)	1-2 lb/acre	-	4	?	Labeled for caterpillars.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	?	Labeled for caterpillars.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	?	Labeled for caterpillars.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	?	Labeled for caterpillars.

Table 15.7 Pesticides for Management of European Corn Borer					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	

PHI = pre-harvest interval, REI = restricted entry interval.   - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

15.8 Wireworms. Primarily the **Wheat Wireworm**, *Agriotes mancus*; **Eastern Field Wireworm**, *Limonius ectypus*; and to a lesser extent, **Corn Wireworm**, Melanotus communis

Time for concern: June through September

Key characteristics: 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. The head and thorax of adults are dark brown; the legs and wing covers vary from pale yellow to mahogany. Eggs are small, pearly white, and spherical. The newly hatched larva or wireworm is white and 2/25 inch long. Mature larvae are cylindrical, tan, and range from 1/2 to 1 inch in length. Wireworms can create holes in potato tubers. See Cornell life cycle and damage (Reference 118).

Relative risk: Wireworm can be serious especially if potatoes are grown in fields directly after sod, grassy weeds, or hay.

Management Option	Recommendation for Wireworms
Scouting/thresholds	Prior to planting, bait stations can be used to monitor populations. Delay sampling as late in the spring as possible because wireworms burrow deep into the soil in the winter and move up only after the soil warms. Place several ounces of coarse whole-wheat flour or a mixture of untreated corn and wheat seed or pieces of carrot or potato into a fine mesh pouch (e.g. panty hose), and bury six to 14 inches. Cover the soil over the bait station first with a piece of black polyethylene plastic and then with a piece of clear polyethylene film. Secure the edges of the film with soil. Prior to planting, remove the soil above and around the bait station and count the larvae in and around the bait. Alternatively, sample in midsummer by sifting one square foot of soil to a depth of six to 14 inches and counting the wireworms. Use a box with a base made of 1/4-mesh hardware cloth as a sieve. Take six to 12 samples, starting in low, wet areas. Threshold: if half or more of the bait stations or soil samples contain one or more wireworms, don't plant potatoes on that ground.
Site selection	Avoid planting in poorly drained soils or wet areas.
Crop rotation	Allow 3 years between grassy crops or cover crops to avoid wireworm with the exception of grains or grasses that are only in the field for part of the season. Millipedes are sometimes found in association with wireworms and produce similar damage to tubers. Rotations of red or sweet clover of more than one year may promote millipede populations.
Cover crops	Full season cover crops can allow wireworm populations to build. Use shorter season or fall seeded cover crops and cultivate into soil in the spring to avoid buildup.
Resistant varieties	No resistant varieties are available.
Cultivation	Cultivation is effective at reducing wireworm populations.
Sanitation	Infestation can be minimized by keeping land free of grassy weeds during the egg-laying period (May through late June).
Notes	Avoid having actively decomposing organic matter during the growing season..

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.8 Pesticides for Management of Wireworms

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre soil drench	0	4	?	
AzaGuard (azadirachtin)	8-16 fl oz/acre soil drench	0	4	?	
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2 soil drench	0	4	?	
AzaSol (azadirachtin)	6 oz/acre soil drench	-	4	?	
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre soil drench	-	12	?	
Ecotec-G (clove oil, cinnamon oil, thyme oil)	22-28 lb/acre band	-	-	?	25(b) pesticide.
PFR-97 20% WDG (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre soil treatment	-	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.9 Symphylan, *Scutigerella immaculata*

Time for concern: May through July

Key characteristics: Garden symphylans, sometimes called garden centipedes, are soil inhabiting arthropods of the Class Symphyla, with 14 body segments and 12 pairs of legs. The quick moving adults are less than ½ inch long, white and slender with prominent antennae. Immature stages only have six pairs of legs. They feed on decaying organic matter and root hairs, stems and tubers. See National Sustainable Agriculture Information Service publication (Reference 119) for photos and more information.

Relative risk: This pest is rare and only occurs sporadically in certain fields and in localized areas within a field.

Management Option	Recommendation for Symphylan
Scouting/thresholds	Record pest history and avoid planting in fields with a history of symphylans. Thresholds have not been established for organic production
Resistant varieties	No resistant varieties are available.
Crop rotation	Potato crops are very effective at reducing symphylan populations. A spring oat winter cover crop has been shown to reduce symphylan populations. Mustard and spinach are good hosts for symphylans and may increase populations.
Site selection, Postharvest, and Sanitation	These are currently not viable management options.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.9 Pesticides for Management of Symphylan

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Azera (🐝azadirachtin, 🐝pyrethrins)	1-3.5 pts/acre soil drench	-	12	?	
Ecotec-G (clove oil, cinnamon oil, thyme oil)	22-28 lb/acre band	-	-	?	25(b) pesticide.
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	?	25(b) pesticide.
PFR-97 20% WDG (*Isaria fumosorosea* Apopka str. 97)	1-2 lb/acre soil treatment	-	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

🐝 Active ingredient meets EPA criteria for acute toxicity to bees

15.10 Spider Mites, *Tetranychus spp.*

Time for concern: July through September

Key characteristics: Tiny, spider-like creatures but without narrow waist between head and body. Adults have 4 pairs of legs (3 pairs in immatures). Adults have 2 well-defined reddish-brown spots on top of body. Infested areas on leaves may be somewhat circular in appearance and are often confused with lightning strikes or wet depressions in fields. See life cycle and damage (Reference 120)

Relative risk: Sporadic problem. Some varieties are more prone to spider mite damage.

Management Option	Recommendation for Spider Mites
Scouting/thresholds	Scout fields weekly beginning in early July and pay special attention to edges of fields bordered by field roads, ditches and other grassy areas. Examine at least 20 leaves from each of these areas using 5-10X magnification. Treatment is recommended if spider mite densities reach or exceed an average of 10 adult mites per leaf. Spot or edge treatment of infested areas is encouraged, if practical.
Site selection	Avoid planting susceptible varieties where they will be subject to repeated dusting from field or road traffic.
Resistant varieties	Spider mites are infrequent pests on most varieties. However, during hot and dry conditions, several varieties (Nordonna, Norgold Russet, NY E11-45 and Marcy) have been reported as susceptible to spider mite infestations especially in those areas of fields subject to heavy dusting from field roads.
Natural enemies	Naturally occurring predators, parasitoids, and pathogens help suppress infestations. Use Reference 94 or Cornell's Guide to Natural Enemies (Reference 95) to identify natural enemies.
Seed selection/treatment, Postharvest, and Sanitation	These are currently not viable management options.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.10 Pesticides for Management of Spider Mites

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre soil drench	0	4	?	
AzaGuard (azadirachtin)	10-16 fl oz/acre soil drench	0	4	?	
AzaMax (azadirachtin)	1.33 fl oz/ 1000 ft^2 soil drench	0	4	?	
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/ 1000 ft^2	0	4	?	
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre soil drench	-	12	?	
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.
Cinnerate (cinnamon oil)	13-30 fl oz/100 gal water	-	-	1	25(b) pesticide. Oil based products effective in 1/1 trial.Check for phytotoxicity before applying to whole crop.
DES-X (insecticidal soap)	2% solution	1/2	12	?	
Ecotec (Rosemary oil, Peppermint oil)	1-4 pts/acre	-	-	1	25(b) pesticide.Oil based products effective in 1/1 trial.
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	?	25(b) pesticide.
Garlic Barrier AG (garlic juice)	1 gal/ 99 gal water	-	-	?	25(b) pesticide.
GC-Mite (garlic oil, clove oil, cottonseed oil)	1 gal/100 gal water	-	-	1	25(b) pesticide. Oil based products effective in 1/1 trial.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	1	See label for specific application volumes. Oil based products effective in 1/1 trial.
GrasRoots (cinnamon oil)	1 part GrasRoots to 9 parts water	-	-	?	25(b) pesticide.
Organic JMS Stylet-Oil (parrafinic oil)	3-6 qt/100 gal water	0	4	1	Foliage contact and coverage extremely important. Do not apply within 10-14 days of sulfur applications. Oil based products effective in 1/1 trial.
Micro Sulf (sulfur)	5 lb/acre	-	24	1	Elemental sulfur effective in 2/3 trials. Does not provide immediate mortality. Foliage contact and coverage extremely important.
Microthiol Disperss (sulfur)	5-10 lb/acre	-	24	1	Elemental sulfur effective in 2/3 trials.

Table 15.10 Pesticides for Management of Spider Mites					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
M-Pede (insecticidal soap)	1-2% volume to volume	0	12	1	Soap based products effective in 2/3 trials.
Nuke Em Natural Insecticide and Fungicide (citric acid)	1 fl oz/31 oz water to 2 fl oz/30 fl oz water	-	-	?	25(b) pesticide.
Oleotrol-I Bio-Insecticide Concentrate (soybean oil)	1 part Oleotrol-I with 300 parts water	-	-	1	25(b) pesticide. Oil based products effective in 1/1 trial.
Organocide (sesame oil)	1-2 gal/100 gal water	-	-	1	25(b) pesticide.Oil based products effective in 1/1 trial.
PFR-97 20% WDG (*Isaria fumosorosea* Apopka str. 97)	1-2 lb/acre soil treatment	-	4	?	Repeat at 3-10 day intervals as needed to maintain control.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	1	Oil based products effective in 1/1 trial.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	?	
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	0	12	?	
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water	until dry	12	?	
Sil-Matrix (potassium silicate)	0.5-1% solution	0	4	?	
SuffOil-X (aliphatic petroleum solvent)	1-2 pt/100 gal water	up to day	4	1	Do not mix with sulfur products. Oil based products effective in 1/1 trial.
Thiolux (sulfur)	3-5 lb/acre	-	24	1	Elemental sulfur effective in 2/3 trials. Labeled only for use against red spider mites.
Trilogy (neem oil)	1-2% solution in 25-100 gal of water/acre	up to day	4	2	Maximum labeled rate of 2 gallons/acre/application. Neem oil effective in 1/2 trials against mites in the greenhouse. Bee Hazard. This product is toxic to bees exposed to direct contact.
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	1	Oil based products effective in 1/1 trial. Apply as needed.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. . PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

15.11 Slugs and Snails

Time of concern: Early spring and fall

Key characteristics: See Rothamsted slug control publication (Reference 121).

Relative risk: Sporadic but wet weather and poorly composted organic matter favor population increase.

Management Option	Recommendation for Slugs and Snails
Slug biology	Slugs and snails are similar in biology except slugs lack an external spiral shell. Pest species have up to 2 generations per year and eggs are laid in the spring and/or fall. Eggs deposited in the fall overwinter and hatch the following spring, usually in April and May. Slugs and snails thrive under the humid canopy of potato crops and can cause significant damage to tubers. Holes and cavities created by feeding of these mollusks are sometimes similar in appearance to (and confused with) that caused by soil arthropods such as millipedes, cutworms and white grubs.
Molluscicide use	For best results, apply in the evening by broadcasting or by row banding to moist soil or after heavy rains. Avoid placing molluscide baits in piles.
Scouting	Low-lying areas and water-filled wheel tracks are excellent places to monitor for the presence of these pests during the period just preceding tuber sizing.
Site selection	Slugs and snails are general organic matter feeders; weedy potato fields and heavy moist soils may favor build-up of these pests. Potato crops following peas may be at greater risk of slug and snail attack in moist years compared to rotations following grains.
Crop rotation	Poorly drained soils, habitually wet areas of fields and weedy fields may be at greatest risk of infestation.
Resistant varieties	No information on North American resistant varieties is available.
Sanitation	Keeping land free of weeds may reduce the potential for infestation.

At the time this guide was produced, the following materials were available in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. However, pesticides meeting the federal requirements for minimum-risk (25(b)) pesticides do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Link 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 15.11 Pesticides for Management of Slugs and Snails

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2](Days)	REI (Hours)	Efficacy	Comments
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide.
Bug-N-Sluggo (spinosad, iron phosphate)	20-44 lb/acre soil treatment	7	4	?	
Envirepel 20 (garlic juice)	10-32 fl oz/acre	-	-	?	25(b) pesticide.
Garlic Barrier AG (garlic juice)	1 gal/ 99 gal water	-	-	?	25(b) pesticide.

Table 15.11 Pesticides for Management of Slugs and Snails					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2](Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Sluggo AG (iron phosphate)	20-44 lb/acre soil treatment	0	0	?	Apply by broadcast or by row band applicator in the evening to moist soil or after heavy rain. Do not place in piles.
Sluggo Slug and Snail Bait (iron phosphate)	20-44 lb/acre soil treatment	0	0	?	

PHI = pre-harvest interval, REI = restricted entry interval - = pre-harvest interval isn't specified on label.

Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. . PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- not reviewed or no research available. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

Active ingredient meets EPA criteria for acute toxicity to bees

16. Pesticides and Abbreviations Mentioned in this Publication

Table 16.1 Fungicides and Nematicides Mentioned in this Publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Actinovate AG	*Streptomyces lydicus*	73314-1
Actinovate STP	*Streptomyces lydicus*	73314-4
Agricure	*potassium bicarbonate*	70870-1
Badge X2	*copper oxychloride, copper hydroxide*	80289-12
Basic Copper 53	*copper sulfate*	45002-8
BIO-TAM	*Trichoderma asperellum, Trichoderma gamsii*	80289-9-69592
BIO-TAM 2.0	*Trichoderma asperellum, Trichoderma gamsii*	80289-9
Champ WG	*copper hydroxide*	55146-1
Clove oil	*clove oil*	Exempt- 25(b) pesticide
Contans WG	*coniothyrium minitans*	72444-1
*Copper Sulfate Crystals	*copper sulfate pentahydrate*	56576-1
CS 2005	*copper sulfate pentahydrate*	66675-3
Cueva Fungicide Concentrate	*copper octanoate*	67702-2-70051
Decco Aerosol 100 For Treatment of Potato in Storage	*clove oil*	Exempt- 25(b) pesticide
DiTera DF	*Myrothecium verrucaria*	73049-67
Double Nickel 55	*Bacillus amyloliquefaciens str. D747*	70051-108
Double Nickel LC	*Bacillus amyloliquefaciens str. D747*	70051-107
GreenCure	*potassium bicarbonate*	70870-1
MeloCon WG Biological Nematicide	*Paecilomyces lilacinus str. 251*	72444-2
Milstop	*potassium bicarbonate*	70870-1-68539
Mycostop Biofungicide	*Streptomyces griseoviridis str. K61*	64137-5
Mycostop Mix	*Streptomyces griseoviridis str. K61*	64137-9
Nordox 75 WG	*cuprous oxide*	48142-4
Nu-Cop 50DF	*copper hydroxide*	45002-4
Nu-Cop 50 WP	*cupric hydroxide*	45002-7
Nu-Cop HB	*cupric hydroxide*	42750-132
Optiva	*Bacillus subtilis str. QST 713*	69592-26
Organic JMS Stylet Oil	*paraffinic oil*	65564-1
OxiDate 2.0	*hydrogen dioxide, peroxyacetic acid*	70299-12

Table 16.1 Fungicides and Nematicides Mentioned in this Publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
PERpose Plus	hydrogen peroxide/dioxide	86729-1
Prestop Biofungicide	*Gliocladium catenulatum str. J1446*	64137-11
PureSpray Green	*petroleum oil*	69526-9
*Quimag Quimicos Aguila Copper Sulfate Crystal	*copper sulfate*	73385-1
Regalia Biofungicide	*Reynoutria sachalinensis*	84059-3
RootShield Granules	*Trichoderma harzianum Rifai str. T-22*	68539-3
Rootshield WP	*Trichoderma harzianum*	68539-7
RootShield PLUS+ WP	*Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*	68539-9
Serenade ASO	*Bacillus subtilis* str *QST 713*	69592-12 and 264-1152
Serenade MAX	*Bacillus subtilis* str *QST 713*	69592-11 and 264-1151
Serenade Opti	*Bacillus subtilis* str *QST 713*	264-1160
Serenade Soil	*Bacillus subtilis* str *QST 713*	69592-12 and 264-1152
Serifel	*Bacillus amyloliquefaciens*	71840-18
SoilGard	*Gliocladium virens str. GL-21*	70051-3
Taegro Biofungicide	*Bacillus subtilis var. amyloliquefaciens str. FZB24*	70127-5
TerraClean 5.0	*hydrogen dioxide, peroxyacetic acid*	70299-13
Trilogy	*neem oil*	70051-2
Zonix	*Rhamnolipid Biosurfactant*	72431-1

Restricted use pesticide. Restricted-use pesticides can be purchased only by certified applicators and used by certified applicators or by those under the direct supervision of a certified applicator.

Active ingredient meets EPA criteria for acute toxicity to bees

Table 16.2 Insecticides Mentioned in this Publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Aza-Direct	*azadirachtin*	71908-1-10163
AzaGuard	*azadirachtin*	70299-17
AzaMax	*azadirachtin*	71908-1-81268
AzaSol	*azadirachtin*	81899-4
Azatrol EC	*azadirachtin*	2217-836
Azera	*azadirachtin and pyrethrin*	1021-1872
Biobit HP	*Bacillus thuringiensis* subsp. kurstaki str. ABTS-351	73049-54
BioLink	*garlic juice*	Exempt - 25(b) pesticide
BioLink Insect & Bird Repellant	*garlic juice*	Exempt - 25(b) pesticide
BioRepel	*garlic oil*	Exempt - 25(b) pesticide
Bug-N-Sluggo Insect, Slug and Snail Bait	*iron phosphate and spinosad*	67702-24-70051
Cedar Gard	*cedar oil*	Exempt - 25(b) pesticide
Cinnerate	*cinnamon oil*	Exempt - 25(b) pesticide
Deliver	*Bacillus thuringiensis subsp. kurstaki*	70051-69
DES-X	*insecticdal soap*	67702-22-70051
Dipel DF	*Bacillus thuringiensis subsp. kurstaki*	73049-39
Ecotec	*rosemary and peppermint oil*	Exempt - 25(b) pesticide
Ecozin PLUS 1.2% ME	*azadirachtin*	5481-559
Entrust	*spinosad*	62719-282
Entrust SC	*spinosad*	62719-621
Envirepel	*garlic juice*	Exempt - 25(b) pesticide
GC-Mite	*cottonseed, clove, and garlic oils*	Exempt - 25(b) pesticide
Garlic Barrier	*garlic juice*	Exempt - 25(b) pesticide
Glacial Spray Fluid	*mineral oil*	34704-849

Table 16.2 Insecticides Mentioned in this Publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Grandevo	*Chromobacterium subtsugae str. PRA*	84059-17
GrasRoots	*cinnamon oil*	Exempt - 25(b) pesticide
Javelin WG	*Bacillus thuringiensis subsp. kurstaki*	70051-66
M-Pede	*potassium salts of fatty acids*	10163-324
Micro Sulf	*sulfur*	55146-75
Microthiol Disperss	*sulfur*	70506-187
Molt-X	*azadirachtin*	68539-11
Neemix 4.5	*azadirachtin*	70051-9
Nuke Em	*citric acid*	Exempt - 25(b) pesticide
Oleotrol-I	*soybean oil*	Exempt - 25(b) pesticide
Organic JMS Stylet Oil	*mineral oil*	65564-1
Organocide 3-in-1	*sesame oil*	Exempt - 25(b) pesticide
PFR-97 20% WDG	*Isaria fumosorosea Apopka str. 97*	70051-19
PureSpray Green	*petroleum oil*	69526-9
Pyganic EC 1.4[II]	*pyrethrins*	1021-1771
PyGanic EC 5.0 [II]	*pyrethrins*	1021-1772
Safer Brand #567	*pyrethrin and soap*	59913-9
Seduce Insect Bait	*spinosad*	67702-25-70051
Sil-Matrix	*potassium silicate*	82100-1
Sluggo-AG	*iron phosphate*	67702-3-54705
Sluggo Slug & Snail Bait	*iron phosphate*	67702-3-70051
SuffOil-X	*petroleum oil*	48813-1-68539
Surround WP	*kaolin*	61842-18
Thiolux	*sulfur*	34704-1079
Trilogy	*neem oil*	70051-2
TriTek	*petroleum oil*	48813-1
Xen Tari	*Bacillus thuringiensis subsp. aizaiwi*	73049-40

Active ingredient meets EPA criteria for acute toxicity to bees

Table 16.3 Sprout Suppressants Mentioned in this Publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Decco 070 EC Potato Sprout Inhibitor	*clove oil*	Exempt - 25(b) pesticide
Decco Aerosol 100 For Treatment of Potato in Storage	*clove oil*	Exempt - 25(b) pesticide
Peppermint oil	*peppermint oil*	Exempt - 25(b) pesticide
Clove oil	*clove oil*	Exempt - 25(b) pesticide

Table 16.4 Sanitizers mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
CDG Solution 3000	*chlorine dioxide*	75757-2
Enviroguard Sanitizer	*hydrogen peroxide/peroxyacetic acid*	63838-1-527
Oxine	*chlorine dioxide*	9804-1
Oxonia Active	*hydrogen peroxide/peroxyacetic acid*	1677-129
Peraclean 5	*hydrogen peroxide/peroxyacetic acid*	54289-3
Peraclean 15	*hydrogen peroxide/peroxyacetic acid*	54289-4
Perasan 'A'	*hydrogen peroxide/peroxyacetic acid*	63838-1
Per-Ox	*hydrogen peroxide/peroxyacetic acid*	833-4
Pro Oxine	*chlorine dioxide*	9804-9
SaniDate 5.0	*hydrogen peroxide/peroxyacetic acid*	70299-19
SaniDate 12.0	*hydrogen peroxide/peroxyacetic acid*	70299-18

Table 16.4 Sanitizers mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
San-I-King No. 451	*sodium hypochlorite*	2686-20001
Shield-Brite PAA 5.0	*Peroxy acetic acid/hydrogen peroxide*	70299-19-64864
Shield-Brite PAA 12.0	*hydrogen peroxide/peroxyacetic acid*	70299-18-64864
StorOx 2.0	*hydrogen peroxide/peroxyacetic acid*	70299-7
Tsunami 100	*hydrogen peroxide/peroxyacetic acid*	1677-164
Victory	*hydrogen peroxide/peroxyacetic acid*	1677-186
VigorOx 15 F & V	*hydrogen peroxide/peroxyacetic acid*	65402-3
VigorOx LS-15	*hydrogen peroxide/peroxyacetic acid*	65402-3

Abbreviations and Symbols Used in This Publication

A	Acre	N	Nitrogen
APHIS	Animal and Plant Health Inspection Service	NFT	not frost tolerant
AR	annual rye	P	phosphorus
ASO	aqueous suspension-organic	PHI	pre-harvest interval
AS	aqueous suspension	P_2O_5	phosphorus oxide
DF	dry flowable	PR	perennial rye
EC	emulsifiable concentrate	R	resistant varieties
F	flowable	REI	restricted entry interval
HC	high concentrate	WG	water dispersible granular
K	potassium	WP	wettable powder
K2O	potassium oxide	WPS	Worker Protection Standard

17. References

All links accessed 9 May 2016

General

1. Petzoldt, C. (2009). *Chapter 24: Potatoes. Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production.* A Cornell Cooperative Extension Publication. Cornell University.(https://ipmguidelines.org/).

2. Caldwell, B. Rosen, E. B., Sideman, E., Shelton, A. M., Smart, C. (2013). *Resource Guide for Organic Insect and Disease Management: Second Edition.* New York State Agricultural Experiment Station, Geneva, NY. (http://web.pppmb.cals.cornell.edu/resourceguide/pdf/resource-guide-for-organic-insect-and-disease-management.pdf).

3. Pesticide Product Ingredient, and Manufacturer System (PIMS), Pesticide Management Education Program, Cornell University Cooperative Extension, Ithaca, NY. (http://pims.psur.cornell.edu/).

4. The Network for Environment and Weather Awareness (NEWA). New York State Integrated Pest Management Program. (http://newa.cornell.edu/).

5. Clark, Diane, ed. (2008). *Pest Management Strategic Plan for Organic Potato Production in the West: Summary of workshops held on February 16, 2006 Buhl, Idaho and January 9, 2008 Portland, Oregon* (http://www.ipmcenters.org/pmsp/pdf/CA-CO-ID-OR-WAOrganicPotatoPMSP.pdf).

6. Kuepper, G. (2009). *Colorado potato beetle: organic control options.* National Sustainable Agriculture Information Service (ATTRA). Publication #CT107. (http://attra.ncat.org/attra-pub/coloradopotato.html#varietal).

7. Stivers, L. (1999). *Crop Profile for Potatoes in New York*. Cornell Cooperative Extension. Cornell University. (http://www.ipmcenters.org/cropprofiles/docs/nypotatoes.pdf).

Certification

8. Organic Materials Review Institute. (http://www.omri.org/).

9. Organic Materials Review Institute. *Adjuvants*. (http://www.omri.org/ubersearch/results/adjuvant?type%5b%5d=opd_listed_product&type%5b%5d=opd_prohibited_product&type%5b%5d=opd_removed_product&cl%5b%5d=16997&rb%5b%5d=17013

10. New York Department of Agriculture and Markets, *Organizations Providing Organic Certification Services for Producers and Processors in New York State*. (https://www.ams.usda.gov/services/organic-certification/certifying-agents).

11. New York Department of Agriculture and Markets, *Organic Farming Development/Assistance*. (http://www.agriculture.ny.gov/AP/organic/index.html).

12. Agriculture Marketing Service, *National Organic Program*. (http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPNationalOrganicProgramHome&acct=AMSPW).

13. National Sustainable Agriculture Information Service, *Organic Farming*. (http://attra.ncat.org/organic.html).

14. Rodale Institute. (http://www.rodaleinstitute.org/).

14a United States Environmental Protection Agency. Pesticide Worker Safety. Pesticide Worker Protection Standard "How To Comply" Manual. (2005) (https://www.epa.gov/pesticide-worker-safety/pesticide-worker-protection-standard-how-comply-manual).

14b National Pesticide Information Center: State Pesticide Regulatory Agencies. Cooperative agreement between Oregon State University and the U.S. Environmental Protection Agency. (http://npic.orst.edu/reg/state_agencies.html).

14c Pesticide Management Education Program (PMEP). (2013). Cornell University Cooperative Extension. (http://psep.cce.cornell.edu/Default.aspx).

14d United States Environmental Protection Agency (2016). Pesticide Worker Safety. Revisions to the Worker Protection Standard. (https://www.epa.gov/pesticide-worker-safety/revisions-worker-protection-standard)

Soil Health and Cover Crops

15. Magdoff, F., Van Es, H. (2010). Sustainable Agriculture Research and Education. *Building Soils for Better Crops, 3rd Edition*. E-book. (http://www.sare.org/publications/bsbc/bsbc.pdf).

16. Comprehensive Assessment of Soil Health Website, Cornell University. (http://soilhealth.cals.cornell.edu/).

17. Björkman, T. Cornell University, *Cover Crops for Vegetable Growers*: *Decision Tool* (http://covercrops.cals.cornell.edu/decision-tool.php).

18. Stivers, L.J., Brainard, D.C. Abawi, G.S., Wolfe, D.W. (1999). *Cover Crops for Vegetable Production in the Northeast.* Cornell Cooperative Extension, Ithaca, NY. (http://ecommons.library.cornell.edu/bitstream/1813/3303/2/Cover%20Crops.pdf).

19. Sarrantonio, M. (1994). *Northeast Cover Crop Handbook*. Rodale Institute, PA. (http://www.johnnyseeds.com/p-7976-northeast-cover-crop-handbook.aspx).

20. Larkin, R. P. and Griffin, T. S. (2007). *Control of soilborne potato diseases using Brassica green manures*. Crop Protection. Volume 26, Issue 7, July 2007. pp1067-1077.

21. Mohler, C. L. and Johnson, S. E., editors. (2009). *Crop Rotation on Organic Farms: A Planning Manual.* Sustainable Agriculture Research and Education. Natural Resource, Agriculture and Engineering Service. Cooperative Extension, Ithaca NY. (http://www.nraes.org/nra_crof.html).

22. Sexton, Peter, Plant, Andrew, Johnson, Steven B. (2007). *Effect of a mustard green manure on potato yield and disease incidence in a rainfed environment.* (https://www.agronomy.org/publications/cm/abstracts/6/1/2007-0122-02-RS?access=0&view=pdf). Crop Management dol:10.1094. Univ. Maine Cooperative Extension.

Weed Management

23. Bowman, G. (2001). The Sustainable Agriculture Network. *Steel in the Field.* Beltsville, MD. E-book. (http://nydairyadmin.cce.cornell.edu/uploads/doc_20.pdf).

24. Cornell University, *Weed Ecology and Management Laboratory*. (http://weedecology.css.cornell.edu/index.php).

25. Rutgers University, *New Jersey Weed Gallery* (http://njaes.rutgers.edu/weeds/).

26. University of Vermont, *Videos for Vegetable and Berry Growers*. (http://www.uvm.edu/vtvegandberry/Videos/weedvideo.htm).

27. Sullivan, P., National Sustainable Agriculture Information Service (formerly ATTRA), *Principles of Sustainable Weed Management for Croplands*. (http://attra.ncat.org/attra-pub/weed.html).

28. Colquhoun, J. and Bellinder, R. (1997). *New Cultivation Tools for Mechanical Weed Control in Vegetables*. Cornell University, (http://www.vegetables.cornell.edu/weeds/newcultivationmech.pdf).

29. Stone, Alex, Producer. *Weed 'Em and Reap Videos*. Department of Horticulture. Oregon State University. (http://horticulture.oregonstate.edu/content/videos-oregon-vegetables).

30. Diver, S. (2002). *Flame Weeding for Vegetable Crops*. National Sustainable Agriculture Information Service (ATTRA). (https://attra.ncat.org/attra-pub/viewhtml.php?id=110).

31. Grubinger, V. Else, M.J. *Vegetable Farmers and their Weed-Control Machines*. (http://www.uvm.edu/vtvegandberry/Videos/weedvideo.htm).

Planting methods

32. *New York State Certified Seed Potatoes 2015Crop Directory*. New York Seed Improvement Project. 103C Leland Lab, Cornell University, Ithaca, NY 14853. (http://rvpadmin.cce.cornell.edu/uploads/doc_331.pdf).

33. Maine Seed Potatoes Certified 2015-16. Department of Agriculture Food and Rural Se rvices, Division of Plant Industry. 744 Main St. Suite 9, Presque Isle, ME 04769. (http://www.maine.gov/dacf/php/seed_potato/20142015FloridaTestBook.pdf).

34. *Colorado Certified Potato Growers Association*. P.O. Box 267, Monte Vista, CO 81144. (http://www.coloradocertifiedpotatogrowers.com/field-readings).

35. Smith-Heavenrich, Sue. (2007). *Greensprouting Potatoes Gives Northern Growers a Head Start*. Maine Organic Farmers and Gardeners Association (http://www.mofga.org/Publications/MaineOrganicFarmerGardener/Spring2007/GreensproutingPotatoes/tabid/706/Default.aspx).

Fertility

36. Agri Analysis, Inc., (http://www.agrianalysis.com/).

37. A&L Eastern Agricultural Laboratories, Inc, (http://al-labs-eastern.com/).

38. The Pennsylvania State University, Agricultural Analytical Services Laboratory, (http://aasl.psu.edu/).

39. University of Massachusetts, Soil and Plant Tissue Testing Laboratory, (http://www.umass.edu/soiltest).

40. Agro One Cooperative Inc., Ithaca, NY, (http://dairyone.com/analytical-services/agronomy-services/soil-testing/).

41. Analytical Laboratory and Maine Soil Testing Service, University of Maine.(http://anlab.umesci.maine.edu/).

42. Rosen, C., Bierman, P. Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops. University of Minnesota. (http://www.extension.umn.edu/distribution/horticulture/M1192.html).

42a. Penn State Agronomy Guide. (2015-16). The Pennsylvania State University, Department of Agronomy. University Park, PA (extension.psu.edu/agronomy-guide).

42b Sánchez, E. S. and Richard, T. L., (2009). Pennsylvania State University Publication, UJ256. *Using Organic Nutrient Sources.* (http://extension.psu.edu/publications/uj256 .)

42c DuPont, T. (2011) Pennsylvania State University Publication, *Determining Nutrient Applications for Organic Vegetables*. (http://extension.psu.edu/business/start-farming/soils-and-soil-management/determining-nutrient-applications-for-organic-vegetables-basic-calculations-introduction-to-soils-fact-3).

Harvest and Storage

43. Frazier, M. J., Olsen, N. and Kleinkopf, G. (2004). *Organic and Alternative Methods for Potato Sprout Control in Storage*. University of Idaho, college of Agriculture and Life Science. (http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1120.pdf).

44. National Organic Standards Section 205.605 and 205.606. (https://www.law.cornell.edu/cfr/text/7/205.605 and https://www.law.cornell.edu/cfr/text/7/205.606). Agriculture Marketing Service, National Organic Program.

45. Griffiths, H. M. and Zitter T. A. (2009). *Postharvest and Storage 2009.* Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PotatoHarvestStorageAug2009.pdf).

Using Organic Pesticides

46. Cornell Integrated Crop and Pest Management Guidelines (2009). *Pesticide Information and Safety*. (https://ipmguidelines.org/).

47. Pesticide Environmental Stewardship: Promoting Proper Pesticide Use and Handling. *Calibrating backpack sprayers.* (http://pesticidestewardship.org/calibration/Pages/BackpackSprayer.aspx).

48. Pesticide Environmental Stewardship: Promoting Proper Pesticide Use and Handling: Calibration. http://pesticidestewardship.org/calibration/Pages/default.aspx .

49. Landers, A. *Knapsack Sprayers: General Guidelines for Use*. Cornell University, Ithaca, N.Y. (http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fweb.entomology.cornell.edu%2Flanders%2Fpestapp%2Fpublications%2Fveg%2Fknapsack%2520sprayer.doc&ei=IV4sVb6TBbSZsQSsnYGgCQ&usg=AFQjCNEahC-v_zsEx6lCmwTqxLFNHne67A&sig2=qbr39wvAcFqaLDoSeDOyTQ&bvm=bv.90790515,d.cWc).

50. Miller, A., Bellinder, R. (2001) *Herbicide Application Using a Knapsack Sprayer*. Department of Horticultural Science, Cornell University, Ithaca, N.Y. (http://www.hort.cornell.edu/bellinder/spray/southasia/pdfs/knapsack.pdf).

51. Federal Insecticide Fungicide Rodenticide Act (FIFRA). (2009). *Electronic Code of Federal Regulations*. Title 40: Protection of the Environment. Part 152 Pesticide registration and classification procedures. Subpart B- exemptions. Part 152.25(b). (http://www.law.cornell.edu/cfr/text/40/152.25).

51a. Office of prevention, pesticides and toxic substances. (2009). *Inert ingredients eligible for FIFRA 25(b) pesticide products*. United States Environmental Protection Agency. Washington DC. (http://www.epa.gov/opprd001/inerts/section25b_inerts.pdf).

52. Federal Insecticide Fungicide Rodenticide Act (FIFRA). (2009). *Electronic Code of Federal Regulations*. Title 7: Agriculture. National Organic Program, Part 205, sections 600-606. (http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr;sid=fbbd316a3eb4c0f243da74a9942b07d8;rgn=div7;view=text;node=7%3A3.1.1.9.32.7.354;idno=7;cc=ecfr).

53. Stewardship Community. *Knapsack Users Training Modules*. . (http://www.stewardshipcommunity.com/resource-centre/downloads/training-modules.html).

53a. Extension: A Part of the Cooperative Extension System. (2016) Pesticide Environmental Stewardship. (http://www.extension.org/pesticidestewardship).

53b. Center for Integrated Pest Management. Pesticide Environmental Stewardship: Promoting Proper Pesticide Use and Handling. (http://pesticidestewardship.org/Pages/About.aspx).

53c. Landers, Andrew. Cornell University Department of Entomology. (2003) Vegetable Spraying. (http://web.entomology.cornell.edu/landers/pestapp/vegetable.htm).

Disease Management

54. MacNab, A. A. and Zitter, T. A. *Do rotations matter within disease management programs?* Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/McNabRotations.htm).

55. Zitter, T. A., and R. Loria. (1986). *Detection of potato tuber diseases and defects.* Cornell Cooperative Extension Information Bulletin 205. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Detection.htm).

56. Rowe, R. C., Miller, Sally A., and Riedel, Richard M. (1995). *Black leg, aerial stem rot and tuber soft rot of potato.* Ohio State University Extension Fact Sheet, Plant Pathology, 2021 Coffey Road, Columbus, OH. (http://www.oardc.ohio-state.edu/sallymiller/extension/factsheets/blklegpotato.pdf).

57. Zitter, T. A. (2009). Cornell Vegetable MD online. *Disease Fact Sheets Listed by Crop.* (http://vegetablemdonline.ppath.cornell.edu/cropindex.htm).

58. Loria, R. (1993). *Fusarium dry rot of potato.* p. 726.10. In: Vegetable/Horticultural Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva.(http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Fusarium.htm).

59. Zitter, T. A. (1984). *Potato early blight*, p. 725.60. In: Vegetable Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_EarlyBlt.htm).

60. Wharton, P. and Kirk, W. (2009). *Michigan Potato Diseases: Early Blight*. Department of Plant Pathology, Michigan State University. (http://www.potatodiseases.org/earlyblight.html).

61. Fry, W.E. (1998). *Late Blight of Potatoes and Tomatoes*, p. 726.20 In: Vegetable Crops: diseases of Vegetables. New York Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_LateBlt.htm).

62. Apple, A. E., and Fry, W. E. (1983). *Potato late blight*, p. 725.40. In: Vegetable Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_LateBlt1983.htm).

63. Zitter. T. A. (2000). *Late Blight Control: What are the options?* Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/LateBlightNews.htm).

63B. McGrath. M. T. (2010). Managing Late Blight in organically produced potatoes. Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Pot_LB_OrganicMgt10.html).

64. *USAblight*. A National Project on Tomato and Potato Late Blight in the United States. (http://www.usablight.org).

65. Zitter, T. A., Hsu, L, and Halseth, D. E. (1989). *Black dot disease of potato*, p. 725.70. *In* Vegetable Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_BlkDot.htm).

66. Zitter, T. A. (2009). *Black dot, black scurf and silver scurf movie: spinning potato*. Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/PhotoPages/Spin/Pot_spin.html).

67. Wharton, P and Kirk, W. (2009). *Black Dot.* Michigan Potato Diseases. Michigan State University. (http://www.potatodiseases.org/blackdot.html).

68. Loria, R., Leiner, R. and Carling, D. (1993). *Rhizoctonia disease of potato,* p. 726.00. UInU Vegetable Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Rhizoctonia.htm).

69. Wharton, P., Kirk, W., Berry, D. and Snapp, S. (2009). *Rhizoctonia stem canker and black scurf of potato*. Michigan State University (http://www.potatodiseases.org/rhizoctonia.html).

70. Steere, L. and Kirk, W. (2015) Michigan State University. Michigan Potato Diseases: *Botrytis Blight* (Gray Mold and Tan Spot) Extension Bulletin E-3205. (http://www.potatodiseases.org/pdf/Botrytis-Grey-Mold.pdf).

71. Wharton, P. Kirk, W. (2013). *Michigan Potato Diseases: White Mold.* Department of Plant Pathology, Michigan State University. (http://www.potatodiseases.org/whitemold.html).

72. Loria, R. (1991). *Potato scab.* p. 725.80. In: Vegetable/Horticultural Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Scab.htm).

73. Personal communication Alec Erlich. (2009). Agric R&D Mgr, Small Planet Foods/General Mills Sedro-Woolley, WA 360.855.2726

74. Christ, Barbara J. (1998). *Identifying potato diseases in Pennsylvania.* Penn State College of Agriculture and Life Sciences. (http://pubs.cas.psu.edu/FreePubs/pdfs/agrs75.pdf).

75. Rowe, R. C., Miller, S. A., and Riedel, R. (1995). *Bacterial Ring Rot of Potatoes*. Ohio State University Extension Fact Sheet. (http://www.oardc.ohio-state.edu/sallymiller/extension/factsheets/bacterial%20ring%20rot%20potato.pdf).

76. Zitter, T. A. (2002). *Update on Pink Rot and Pythium Leak Control for Potatoes.* Vegetable MD online. Cornell University. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Potato_Pink_Leak.htm#Images).

77. Wharton, P and Kirk, W. (2009). Michigan Potato Diseases. *Pink Rot.* http://www.potatodiseases.org/pinkrot.html

78. Miller, J. S., Clayson, S. and Miller, T. D. (2006). *Using all the tools in the Pink Rot Management Toolbox*. Idaho Center for Potato Research and Education. ().

79. Johnson, S. B. (2002). Powdery scab of potato. University of Maine Cooperative Extension Bulletin #2436. (http://extension.umaine.edu/publications/2436e/).

80. Larkin, R. (2008). Effective Rotation Crops for Control of powdery scab and other soilborne diseases. Soilborne disease project research report. University of Maine. Orono ME 04469.

81. Hamm, P.B., Johnson, D.A., Miller, J.S., Olsen, N.L. and Nolte, P. (updated 2013) Pacific Northwest Extension Publication. Silver Scurf Management in Potatoes. PNW 596. (https://catalog.extension.oregonstate.edu/files/project/pdf/pnw596.pdf).

82. Merida, C. L., and Loria, R. (1991). *Silver scurf of potato*. p. 725.90. In: Vegetable/Horticultural Crops: Diseases of Potato. New York State Agricultural Experiment Station, Geneva. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_SilverScurf.htm).

83. Frazier, M. J., Kleinkopf, Gale E. and Olsen, Nora. (2006). *Clove Oil for Potato Sprout and Silver Scurf Suppression in Storage*. University of Idaho, College of Agriculture and Life Sciences. Idaho Potato Conference on January 19, 2006 (http://www.cals.uidaho.edu/edComm/pdf/cis/cis1120.pdf).

84. Zitter, T. A. and Gallenberg. D. J. (1984). *Virus and Viroid diseases of potato*. Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/factsheets/Virus_Potato.htm).

85. Zitter , T. A. (2009). *Virus and Viroid diseases of potato Photo Gallery*. Vegetable MD on line. (http://vegetablemdonline.ppath.cornell.edu/PhotoPages/Potatoes/Viruses/PotVirusFS1.htm).

85B. Burrows, M. E. and Zitter, T. A. (2005). *Virus problems of potatoes.* Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Potato_Virus.htm).

85C. Donald, P. and Jett, L. (2000). *Disease prevention in home vegetable gardens.* University of Missouri extension. (http://extension.missouri.edu/explorepdf/agguides/hort/g06202.pdf).

86. Abawi, G., Ludwig, John W. and Gugino, B. (2008). *Diagnosis, Biology and Management of Root knot and lesions nematodes on potato.* Vegetable MD online. (http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Pot_Nematodes.htm#Fig1).

87. Plant Disease Diagnostic Clinic. Cornell University. (http://plantclinic.cornell.edu/services.html).

88. Abawi, F. S. Gugino, B. K. (2007). Cornell University, New York State Agricultural Experiment Station. *Soil Sampling for Plant-Parasitic Nematode Assessment.* (http://www.fruit.cornell.edu/berrytool/pdfs/Soil%20Sampling%20for%20Nematode%20Assessment%20Factsheet.pdf).

89. Cornell University, New York State Agricultural Experiment Station. *Visual Assessment of Root-Knot Nematode Soil Infestation Levels Using a Lettuce Bioassay*. (http://www.nysipm.cornell.edu/factsheets/vegetables/Soil_Bioassay_Root-Knot.pdf).

90. Gugino, B.K., Ludwig, J.W., Abawi, G.S. Cornell University, New York State Agricultural Experiment Station. *A Soil Bioassay for the Visual Assessment of Soil Infestations of Lesion Nematode*. (http://www.nysipm.cornell.edu/factsheets/vegetables/Lesion_Nematode_Bioassay.pdf).

91. Animal and Plant Health Inspection Service (APHIS). (2008). Factsheet *Plant Protection and Quarantine: Golden nematode*. (http://www.aphis.usda.gov/publications/plant_health/content/printable_version/fs_golden_nematode_08.pdf).

92. Regulatory Control. *Integrated Pest Management: Golden nematode* Cornell University. Entomology/Crop & Soil Science 444 Integrated Pest Management (http://courses.cit.cornell.edu/ipm444/new%20material/Golden_nematode.html).

Insect Management

93. Tingey, W. M. (1999). *Insect control in commercial potato production.* pp. 219-228. In: 2000 Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production. 298 pp.

94. Hoffmann, M. P., and A. C. Frodsham. (1993). *Natural Enemies of Vegetable Insect Pests*. Cornell Cooperative Extension. 64 pp. (http://nysaes-bookstore.myshopify.com/products/natural-enemies-of-vegetable-insect-pests).

95. Weeden, C. R., Shelton, A. M. and Hoffmann, M. P. (updated 2007). *Biological Control: A Guide to Natural Enemies in North America*. Cornell University (http://www.biocontrol.entomology.cornell.edu/index.php).

96. Klass, C. 1974. (updated 2012). *Colorado Potato Beetle*. Insect Diagnostic Laboratory Factsheets. Cornell University. (http://idl.entomology.cornell.edu/files/2013/11/Colorado-Potato-Beetle-u7oiz4.pdf).

97. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Colorado Potato Beetle.* Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/cpb.html).

98. Muka, A. A., and Semel., M. (1983). *Colorado potato beetle*, p. 760.00. *In* Vegetable Crops: Insects of Solanaceous Crops. New York State Agricultural Experiment Station, Geneva. (http://www.nysipm.cornell.edu/factsheets/vegetables/potato/cpb.pdf).

99. Albers, C. W. and Tingey. W. M., producers. (1994). *Colorado potato beetle: controls that minimize insecticide resistance*. 15 min. Cornell Cooperative Extension. Videocassette.

100. Kuepper, G. and Thomas, R. (2002). *Bug vacuums for organic crop protection.* National Sustainable Agriculture and Information Service. ATTRA. (http://attra.ncat.org/attra-pub/bugvacuums.html).

101. Klass, C. (updated 2012). *Aphids.* Insect Diagnostic Laboratory Factsheets. Cornell University. (http://idl.entomology.cornell.edu/files/2013/11/Aphids-2dy8lft.pdf).

102. Hoffmann, M. and Sanderson, J. (1993). *Melon aphid.* p 750.50. In: Vegetable Crops Insects Factsheet. Entomology Cooperative Extension. Cornell University (http://nysipm.cornell.edu/factsheets/vegetables/cucu/ma.pdf).

103. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Green Peach Aphid.* Pests in the Northeastern United States. . (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/gpa.html).

104. Stapleton, J. J. and Summers, C. G. (2002). p. 891-898. *Reflective mulches for management of aphids and aphid-borne virus diseases in late-season cantaloupe (Cucumis melo L. var. cantalupensis).* Crop Protection. Volume 21. Issue 10.

105. Moyer, D. D. and Turner, L. G., producers. (1992). *Alternative Management Techniques for the Colorado Potato Beetle*. Cornell Cooperative Extension. Videocassette. 16 min.

106. Tingey, W. M., and A. A. Muka. (1983). *Potato leafhopper.* p. 760.20.In Vegetable Crops: Insects of Vegetables. New York State Agricultural Station, Geneva. (http://www.nysipm.cornell.edu/factsheets/vegetables/potato/plh.pdf).

107. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Potato leafhopper.* Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/plh.html and http://web.entomology.cornell.edu/shelton/veg-insects-ne/damage/plh_potatoes.html).

108. Klass, C. 1972. (updated 2012). *Flea Beetles.* Insect Diagnostic Laboratory Factsheets. Cornell University. (http://idl.entomology.cornell.edu/files/2013/11/Flea-Beetles-26v5d82.pdf).

109. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Potato flea beetles.* Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/pfb.html and http://web.entomology.cornell.edu/shelton/veg-insects-ne/damage/pfb_potatoes.html).

110. Klass, C. 1975 (updated 2012). *Cutworms.* Insect Diagnostic Laboratory Factsheets. Cornell University. (https://s3.amazonaws.com/assets.cce.cornell.edu/attachments/2089/Cutworms.pdf?1408559687).

111. Chapman, P. J., and Lienk. S. E. (1991). *Flight period(s) of the larger species of moths (MACROLEPIDOPTERA) that occur in Western New York*. New York's Food and Life Sciences Bulletin. New York State Agricultural Experiment Station, Geneva, NY. Cornell University. (https://ecommons.cornell.edu/handle/1813/5201).

112. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Cutworm: Peridroma saucia.* Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/cw.html).

113. Andaloro, J. T., Muka, A. A. and Straub, R. W. (1983). *European corn borer*. p. 794.00. UInU Vegetable Crops: Insects of Corn. New York State Agricultural Experiment Station, Geneva. (http://nysipm.cornell.edu/factsheets/vegetables/swcorn/ecb.pdf).

113A. Schramm, S. and Cullen, E. *Moth identification guide for blacklight trap catch in Wisconsin*. University of Wisconsin Extension Publication #A3855. (http://corn.agronomy.wisc.edu/Management/pdfs/A3855.pdf).

114. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *European Corn Borer* Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/cw.html).

115. Showers, W. B., Witkowski, J. F., Mason, C. E., Calvin, D. D., Higgins, R. A., and Dively, G. P. (1989). *European Corn Borer: Development and Management*. North Central Regional Extension Publication 327. 198 NCR Educational Materials Project, B-10 Curtiss Hall, Iowa State University, Ames, IA 50011. (http://publications.iowa.gov/12587/1/European_Corn_Borer.pdf).

116. Seaman, A., Hoffmann, M.P. and Woodsen, M. M. (2008). *Using Trichogramma ostriniae to help manage European corn borer in sweet corn, peppers and potatoes*. Integrate Pest Management Program, Cornell University. NYSAES. Geneva, NY. (http://nysipm.cornell.edu/factsheets/vegetables/swcorn/trich_ost.pdf).

117. Agriculture and Agri-Food Canada. (2009). *European Corn Borer Crusher for Potatoes*. Pest Management Centre Progress in Potatoes. (http://www.agr.gc.ca/eng/about-us/offices-and-locations/pest-management-centre/publications-and-newsletter/european-corn-borer-crusher-for-potatoes/?id=1205940129823).

118. Wilsey, W. T., Weeden. C. R. and Shelton, A. M. (2007). *Wireworms*. Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/ww.html).

119. Umble, J., Dufour, G., Fisher, G., Fisher, J., Leap, J., Van Horn, Mark. (2006). *Symphylans: Soil Pest management Options*. National Sustainable Agriculture Information Service. (https://attra.ncat.org/attra-pub/summaries/summary.php?pub=127).

120. Wilsey, W. T., Weeden, C. R. and Shelton, A. M. (2007). *Two-spotted spider mites*. Pests in the Northeastern United States. (http://web.entomology.cornell.edu/shelton/veg-insects-ne/pests/tsm.html and http://web.entomology.cornell.edu/shelton/veg-insects-ne/damage/tsm_crops.html).

121. Speiser, B. Glen D. et al. (2001). *Slug damage and control of slugs in horticultural crops*. Integrated Approach to Crop Research (IACR). Rothamsted Research, Harpenden, Hertfordshire. (https://shop.fibl.org/fileadmin/documents/shop/1290-slugs.pdf).

This guide is published by the New York State Integrated Pest Management Program, which is funded through Cornell University, Cornell Cooperative Extension, the New York State Department of Agriculture and Markets, the New York State Department of Environmental Conservation, and USDA-NIFA. Cornell Cooperative Extension provides equal program and employment opportunities. NYS IPM Publication number 138. June 2016. www.nysipm.cornell.edu