http://hdl.handle.net/1813/42892

2016

Organic Production and IPM Guide for Carrots

NYS IPM Publication No. 133

Cornell University Cooperative Extension

IPM Integrated Pest Management

New York State Department of Agriculture & Markets

2016 Production and IPM Guide for **Organic Carrots** for Processing

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Special Appreciation

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

Funded in part by 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 Carrots for Processing.* Publisher: New York State Integrated Pest Management Program, Cornell University (New York State Agricultural Experiment Station, Geneva, NY). 46 pages.

Table of Contents

INTRODUCTION

This guide for organic production of carrots 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.

The 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 that gross 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 (Link 4) operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Development/Assistance web page (Link 5). See more certification and regulatory details under Section 4.1 *Certification Requirements* and Section 10: *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.

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 should occur at least 120 days before harvest). Decomposing plant materials will activate a diverse pool of microbes, including those that breakdown organic matter into plant-available nutrients as well as others that compete with plant pathogens on the root surface.

Rotating between crop families can help prevent the buildup of diseases that overwinter in the soil. Rotation with a grain crop, preferably a crop or crops that will be in place for one or more seasons, deprives most 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 especially the lesion nematode. Rotating between crops with late and early season planting dates can help prevent 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 Building Soils for Better Crops by Fred Magdoff and Harold Van Es, 2010

(Link 10). For additional information, refer to the Cornell Soil Health website (Link 11).

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 populations of beneficial fungi, and may help control insects, diseases and nematodes. To be effective, cover crops should be treated as any other valuable crop on the farm, with their cultural requirements carefully considered including their cultural requirements, life span, mowing recommendations, incorporation methods, and susceptibility, tolerance, or antagonism to root pathogens and other pests. Some cover crops and cash crops share susceptibility to certain pathogens and nematodes. Careful planning and monitoring is required when choosing a cover crop sequence to avoid increasing pest problems in subsequent cash crops. 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 a nutrient management plan.

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 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. Carrot growers should be particularly alert for clover seed contaminated with wild carrot.

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 crop can add nitrogen, smother weeds, or break a pest cycle. 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 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 6) or the Cornell online decision tool to match goals, season, and cover crop (Link 9).

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 crop residue.

3.2 Legume Cover Crops

Legumes are the best cover crop for increasing available soil nitrogen. Legumes have symbiotic bacteria called rhizobia, which live in their roots and 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 fixed nitrogen will be available for the crop to use 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 the organic farm certifier prior to inoculating seed.

3.3 Non-Legume Cover Crops

Barley, rye grain, rye grass, Sudangrass, wheat, oats, and other grain crops left on the surface or plowed under as green manures or dry residue in the spring are beneficial because these plants take up nitrogen that otherwise might be leached from the soil, and release it back to the soil as they decompose. If incorporated, allow two weeks or more for decomposition prior to planting to avoid the negative impact on stand establishment from actively decomposing material. Three weeks might not be enough if soils are very cold. In wet years, this practice may increase slug damage.

3.4 Biofumigant Cover Crops

Certain cover crops have been shown to inhibit weeds, pathogens, and nematodes by releasing toxic volatile chemicals when tilled into the soil as green manures and degraded by microbes or when cells are broken down by finely chopping. Degradation is quickest when soil is warm and moist. These biofumigant cover crops include Sudangrass, sorghum-sudangrasses, and many in the brassica family. Varieties of mustard and arugula developed with high glucosinolate levels that maximize biofumigant activity have been commercialized (e.g. Caliente brands 199 and Nemat).

Attend to the cultural requirements of the cover crops to maximize growth. Fertilizer applied to the cover crops will be taken up and then returned to the soil for use by the cash crop after the cover crop is incorporated. Biofumigant cover crops like mustard should be allowed to grow to their full size, normally several weeks after flowering starts, but incorporated before the seeds become brown and hard indicating they are mature. To minimize loss of biofumigant, finely chop the tissue early in the day when temperatures are low. Incorporate immediately by tilling, preferably with a second tractor following the chopper.

Lightly seal the soil surface using a culti-packer and/or 1/2 inch of irrigation or rain water 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 products to harm the crop, also known as phytotoxicity. Scratching the soil surface before planting will release remaining biofumigant. This biofumigant effect is not predictable or consistent. The levels of the active compounds and suppressiveness can vary by season, cover crop variety, maturity at incorporation, amount of biomass, fineness of chopping, how quickly the tissue is incorporated, soil microbial diversity, soil tilth, and microbe population density.

Resources:

Cover Crops for Vegetable Growers: Decision Tool (Link 9).
Northeast Cover Crops Handbook (Reference 6).
Cover Crops for Vegetable Production in the Northeast (Reference 7).
Crop Rotation on Organic Farms: A Planning Manual (Link 11a).

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

Species	Planting Dates	Life Cycle	Cold Hardiness Zone (Link 1)	Tolerances: Heat	Tolerances: Drought	Tolerances: Shade	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
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	≤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	Biennial	4	6	7-8	4	6.5-7.5	Most	9-20	90-170	+Deep taproot breaks up compacted soils & recycles nutrients

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

Species	Planting Dates	Life Cycle	Cold Hardiness Zone (Link 1)	Heat	Drought	Shade	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
				Tolerances							
	summer										+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 Rodale Institute www.rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook (Reference 6).

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.-	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

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

	late Sept.									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 the Rodale institute http://rodaleinstitute.org/ . M. Sarrantonio. (1994) Northeast Cover Crop Handbook (Reference 6).

4. FIELD SELECTION

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

4.1 Certifying 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 are required between certified organic and conventionally grown crops. 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 genetically engineered crops can also be a contaminant. An organic crop should not be grown near a genetically engineered 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 a 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 11, 12, 13). 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 to 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 can be 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 5: *Weed Management,* and Section 3: *Cover Crops* for more specifics.

Rotating crops that produce abundant organic matter, such as hay crop 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*). Carrots generally have a lower nutrient requirement (Table 4.2.1). Growing a cover crop, preferably one that includes a legume (unless the field has a history of *Pythium* or *Rhizoctonia* problems), prior to or after a carrot crop, will help to renew soil nutrients, improve soil structure, and diversify soil organisms. Deep-rooted crops in the rotation to help break up compacted soil layers.

Table 4.2.1 Crops Nutrient Requirements

	Nutrient Needs		
	Lower	**Medium**	**Higher**
Crop	bean beet carrot herbs pea radish	cucumber eggplant brassica greens pepper pumpkin spinach chard squash winter squash	broccoli cabbage cauliflower corn lettuce potato tomato

From NRAES publication *Crop Rotation on Organic Farms: A Planning Manual.* Charles L. Mohler and Sue Ellen Johnson, editors, (Link 11a).

Table 4.2.2 Potential Interactions of Crops Grown in Rotation with Carrot

Crops in Rotation	**Potential Rotation Effects**	**Comments**
Leek, onion, garlic, potato, rutabaga, turnip, radish,	Causes a *decline* in **soil structure**	Root crops tend to reduce soil structure due to the additional soil disturbance during harvest. Grow "soil building" crops before and after a root crop.
Spring oat cover crop	*Improves* **soil structure**	a spring oat cover crop (often planted with field pea) helps control weeds and restore soil structure after plantings of root crops.
Field pea cover crop	*Improves* soil **nitrogen** *Decreases* **weed pressure**	A spring planted field pea cover crop (often planted with oats) controls weeds and helps restore nitrogen after late harvested crops such as parsnip
Short season crops such as lettuce and spinach	*Decreases* **weed pressure**	Plant short season crops prior to carrot to reduce weed pressures.
Onion, leek	*Increase* in **weed pressure**	Weed control is difficult in crops such as carrots and onions and can lead to heavy weed pressures in subsequent crops.
Bean, lettuce	*Increase in* **Sclerotinia white mold**	Sclerotinia has a wide host range of other crops and weeds. Rotate to a grain crop or sweet corn.
Many hosts	*Reduces* **germination**	Germination may be reduced if carrot is planted in fields with a history of *Pythium* or *Rhizoctonia.*
Carrot, celery, potato, celeriac, parsnip	*Increase* in **Root knot nematode**	2-year rotation sequences with these crops should be avoided to reduce root knot nematodes.

Excerpt from Appendix 2 of Crop Rotation on Organic Farms: A Planning Manual. Charles L. Mohler and Sue Ellen Johnson, editors. (Link 11a)

4.3 Pest History

Knowledge about the pest history for each field is important for planning a successful cropping strategy. Germination may be reduced in fields with a history of *Pythium* or *Rhizoctonia.* Avoid fields that contain heavy infestations of perennial weeds such as nutsedge, 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 to sweet corn or grain crops or treatment with Contans to reduce fungal sclerotia in the soil after an infected crop is harvested. Fields heavily infested with root rot pathogens should also be rotated to a grain crop to reduce infection potential.

If nematodes are not a problem, it is beneficial to grow several short season crops, such as spinach and lettuce, the year before carrots, so that weeds can be killed before they go to seed, but keep a record of root disease severity as it might be increasing.

Carrots are very sensitive to infection by root-knot nematode, *Meloidogyne hapla*, and severe yield losses can result from reduced marketability. It is important to know whether or not this nematode is present in the field in order to develop long-term crop rotations and cropping sequences that either reduce the populations in heavily infested fields or minimize their increase in fields that have no to low infestation levels. Refer to Section 12 for more information on nematodes.

4.4 Drainage and Soil Texture

Most fungal and bacterial pathogens need free water on the plant tissue or high humidity for several hours in order to infect. Any practice that promotes leaf drying or drainage of excess water from the root zone will minimize favorable conditions for infection and disease development. Fields with poor air movement, such as those surrounded by hedgerows or woods, create and environment for prolonged leaf wetness. Plant rows parallel to the prevailing winds, which is typically in an east-west direction, and avoid overcrowding to promote drying of the soil and reduce moisture in the plant canopy.

Carrots need good air and soil drainage for disease management. Obtaining long, straight, smooth roots is difficult. Light-textured soils that contain few stones or well-drained muck soils are preferred.

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, weed management on organic farms must take an integrated approach that includes crop rotation, cover cropping, cultivation, and planting design, based on an understanding of dominant weed biology and ecology of dominant weed species. A multi-year approach that includes strategies for controlling problem weed 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.

5.1 Record Keeping

Scout and develop a written inventory of weed species and severity for each field. Accurate identification of weeds is essential. Management plans should focus on the most challenging and potentially yield-limiting weed species in each field, being sure to emphasize options that do not exacerbate other species that are present. Alternating between early and late-planted, 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.

5.2 Weed Management Methods

Planting and cultivation equipment should be set up on the same number of rows to minimize crop losses and damage to carrot roots during cultivation. It may be necessary to purchase specialized equipment to successfully control weeds in some crops. See resources at the end of this section to help fine-tune your weed management system. Weed fact sheets provide a good color reference for common weed identification. See Cornell Weed Ecology and Rutgers Weed Gallery websites (Links 21-22).

Plant carrots after a fallow year where frequent harrowing was possible, or after a year of short season crops such as spinach and lettuce, where weeds were killed before they went to seed. Be aware that while helping to reduce weeds, using these crops in a rotation can contribute to disease problems. Let the field fallow again before planting. Till the soil, and prepare a rough but settled seedbed. Let the weeds emerge, and then till at a shallow depth to kill them.

Prepare the seed bed, firm it and let a second flush of weeds emerge until the largest are about 1 inch. Go over the bed with a flame weeder, with speed set slow enough to kill every weed. Flaming is recommended because it maintains bed structure and leaves weed seeds undisturbed. The investment in a flame weeder will pay for itself in the first year by saving on hand labor.

Plant carrots and wait about 9 days until just before carrots emerge. Flame the bed again to destroy new weed growth one last time prior to carrot seed emergence.

Allow carrots to become established in this weed free environment. Before weeds reach 2", begin cultivating with a belly mounted or steered rear mounted cultivator. Use vegetable knives adjusted as close to the row as your steering ability permits. Whatever is not cultivated will need hand weeding therefore cultivating as close to the rows possible is recommended. For later cultivations, switch to 4" sweeps next to the row using them to throw soil into the row. This will bury small weed seedlings and keep the shoulder of the carrot root covered.

Resources

Steel in the Field(Link 20).
Cornell Weed Ecology website: (Link 21).
Rutgers University, New Jersey Weed Gallery: (Link 22).
University of Vermont videos on cultivation and cover cropping: (Link 23).
ATTRA Principles of Sustainable Weed Management for Croplands: (Link 24).
New Cultivation Tools for Mechanical Weed Control in Vegetables (Link 25).

6. RECOMMENDED VARIETIES

Variety selection is important both for the horticultural characteristics specified by the processor and the pest resistance profile that will be the foundation of a pest management program. If the field has a known pest history, Table 6.1 can help determine which varieties might be resistant or tolerant of the problem. 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 tree suppliers, organic seed is not available for a particular variety, then the certifier may allow untreated conventional seed to be used.

Blunt-tipped Nantes varieties are preferred for sliced, processed products, and blocky Chantenay or Danvers types are used for diced products.

Table 6.1 Disease Resistance of Selected Carrot Varieties.

Variety	Alternaria Leaf Blight	Cercospora	Bacterial leaf blight	Aster yellows	Cavity Spot	Bolting	Cracking	Carrot type
Abledo[4]						X		Early. Dicing
Abundance								Dicing (new)
Amtou				R				
Bercaro				R				
Bergen[4]	2	1						Slicing (new)
Big Sur	X							
Bolero	1,R	1,R						Slicing
Camarillo[4]								Dicing (new)
Campbells 1364[4]								Dicing
Canterbury[4]								Dicing (new)
Carson[4]	R	2,R						Dicing (new)
Charger				R				
Cordoba[4]	X	X						Dicing (new)
Eagle[4]	3	2						Slicing
El Presidente				R				
Enterprise[4]	X			R				Slicing
Gold King				R				
Growers Choice				R				
GT 26 Dicer				R				
Hi Color 9				R				
Impak				R				
Magnum[4]	X							Slicing
Nanton				R				
Napa		3					X	Slicing
Nevada	X							Slicing
Nimrod				R				
Primecut 59	X	X		R				Slicing
Prodigy								Slicing/Dicing (new)
Prospector				R				
PY 60				R				
Recoleta	X	3		R				Slicing/Dicing (new)
Revo				R				
Rona				R				
Royal Chantenay				R				
Scarlet Nantes				R				
Scarlet Nantes ST				R				
Sierra				R				
Sirocco	X, R	R		R				Slicing
Six Pak				R				

Variety	Alternaria Leaf Blight	Cercospora	Bacterial leaf blight	Aster yellows	Cavity Spot	Bolting	Cracking	Carrot type
Spearhead				R				
Tajoe				R				
Texsun				R				
Top Cut 93[4]	X	X						Slicing
Toudo				R				
Triple Play 58				R				
Upper Cut 25	X							Slicing

1 = highly resistant, 2 = moderately resistant, 3 = no resistance (in replicated trials from NY), 4 Varieties currently grown in NY
X = resistance indicated in seed catalog. R = resistant based on assessments done in Wisconsin. Empty cells indicate that no information is available

7. PLANTING METHODS

The earliest recommended planting date in New York for untreated carrot seed is late April. The crop is harvested in late September and October. To avoid bacterial blight and other diseases, only clean seed should be planted. Seeds can be tested for vigor at a New York State Seed Testing Laboratory (Link 27). Carrots are a cool-season crop that can tolerate light frosts. Good quality roots (judged by length, shape, and color) develop when soil temperature is between 60° and 70°F. At warmer temperatures, the roots will be shorter, and internally the color will be lighter orange.

Carrots are biennial, normally producing an enlarged root the first growing season and, after a prolonged cold period (below 45°F), a seed stalk (assuming that the roots are not allowed to freeze). When spring conditions are especially cool, bolting or premature seed development can occur during the early growing season. If this happens, the root will be woody and inedible. Because large seedlings are more susceptible to bolting than are smaller seedlings, premature seed stalk development is generally associated with early spring plantings. Varieties differ greatly in their susceptibility to bolting.

The length of carrot roots is determined within the first few weeks after germination because the taproot quickly penetrates deep into the soil. If the young taproot is injured, it will become branched and forked, making the root unmarketable. Excessive soil moisture, insects, diseases, nematodes, and soil compaction can all markedly affect root quality. Wet soil near harvest will cause the roots to become rough and promote root rot diseases. Obtaining long, straight, smooth roots is difficult. Light-textured soils that contain few stones or well-drained muck soils are preferred. Primary tillage should be fairly deep, but care must be taken not to impair soil structure by working the soil when wet. Use of raised beds, which tend to increase drainage, aeration, and total depth of tilled soil, can improve the length and shape of roots.

Some carrot varieties (Nantes and related types) are especially susceptible to the formation of chlorophyll (green pigment) on the shoulders and within the core area of the root. To reduce this problem, the soil should be hilled over the shoulders of the roots at the last cultivation.

Table 7.1 Recommended spacing

Type	Row (inches)	Seed In-Row	Pounds /Acre
Nantes	18-36	1.5"	2 to 3
Chantenay or Danvers	18-36	1.5"	1 to 2

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 complements 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	16
Agri Analysis, Inc.		x	13
A&L Eastern Ag Laboratories, Inc.	x	x	14
Cornell Soil Nutrient Analysis Lab	x		12
Penn State Ag Analytical Services Lab.	x	x	15
University of Massachusetts	x	x	17
University of Maine	x	x	18

8.1 Fertility

Recommendations from the Cornell Integrated Crop and Pest Management Guidelines indicate a carrot crop requires 90 lbs. N, 120 lbs. P, and 160 lbs. K per acre. These levels are based on the total needs of the whole plant and assume the use of synthetic fertilizers. Farmer and research experience suggests that lower levels may be adequate in organic systems. See Table 8.2.2 for the recommended rates of P and K based on soil test results. Nitrogen is not included because levels of available N change in response to soil temperature and moisture, N mineralization potential, and leaching. As many of the nutrients as possible should come from cover crop, manure, and compost additions in previous seasons.

Develop a plan for estimating the amount of nutrients that will be released from soil organic matter, cover crops, compost, and manure. A strategy for doing this is outlined in Section 8.2: *Preparing an Organic Nutrient Budget*. It is important to remember that in cool soils, microorganisms are less active, and nutrient release may be too slow to meet the crop needs. Once the soil warms, nutrient release may exceed crop needs. In a long-term organic nutrient management approach, most of the required crop nutrients would be in place as organic matter before the growing season starts. Nutrients required by the crop in the early season can be supplemented by highly soluble organic amendments such as poultry manure composts or organically approved bagged fertilizer products (see Tables 8.2.4 to 8.2.6). These products can be expensive so are most efficiently used if banded at planting. The National Organic Standards Board states that no more than 20% of total N can be applied as Chilean nitrate. Be sure to confirm that the products you select are approved for use in organic by your certifier prior to field application.

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 needs (2-4=)			

Line 1. Total Crop Nutrient Needs: Research indicates that an average carrot crop requires 90 lbs. of available nitrogen (N), 120 lbs. of phosphorus (P), and 160 lbs. of potassium (K) per acre to support a medium to high yield (see section 8.1: *Fertility* above).

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 Recommended Amounts of Phosphorus and Potassium for Carrots Based on Soil Tests

	Soil Phosphorus Level			Soil Potassium Level		
Level shown in soil test	low	med	high	low	med	high
	P_2O_5 lbs/A			K_2O lbs/A		
Total nutrient recommendation	120	80	40	160	120	60

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 3% organic matter could be expected to provide 60 pounds of N per acre.

Line 3b. Manure: Assume that applied manure will release N for 3 years. Based on the test of total N in any manure applied, estimate that 50% is available 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.

Line 3c. Compost: Estimate that between 10 to 25% of the N, 80% of the phosphorous and 90% of the potassium contained in compost will be available 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 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 your farm certifier. Compost generated on the farm must follow an approved process outlined by your 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 the organic matter, 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 (~90 lbs/acre), a sidedress application of organic N may be needed. There are several sources for N for organic sidedressing (see Table 8.2.4) as well as pelleted composts. If early in the organic transition, a grower may consider increasing the N budget supply by 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. **Manure applications may not be allowed by your certifier or marketer even if applied 120 days before harvest. Check with both these sources prior to making manure applications.**

Table 8.2.3 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[4]	20[5]	44	23
Dairy (liquid)	28	13	25	14[4]	11[5]	10	23

1-N1 is an estimate of the total N available for plant uptake when manure is incorporated within 12 hours of application, 2-N2 is an estimate of the 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.) 4- injected, 5- incorporated. Adapted from *"Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops"* by Carl Rosen and Peter Bierman (Link 19).

Tables 8.2.4-8.2.6 lists some commonly available fertilizers, and their nutrient content.

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)[1] 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)[1]	200	400	600	800	1000
Chilean nitrate 16% N cannot exceed 20% of crop's need.	125	250	375	500	625

1 Application rates for some materials are multiplied to adjust for their slow to very slow release rates.

Table 8.2.5 Available Phosphorous in Organic Fertilizer

	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)[1]	270	530	800	1100	1300
Fish meal, 6% P_2O_5 (also contains 9% N)	330	670	1000	1330	1670

1 Application rates for some materials are multiplied to adjust for their slow to very slow release rates.

Table 8.2.6 Available Potassium in Organic Fertilizer

	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, also 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)[1]	8000	16000	24000	32000	40000
Potassium sulfate 50% K_2O	40	80	120	160	200

1 Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Tables 8.2.4 to 8.2.6 adapted by Vern Grubinger from the University of Maine soil testing lab (Link 18).

An example of how to determine nutrient needs for carrots.
You will be growing an acre of carrots. The *Cornell Integrated Crop and Pest Management Guidelines* suggests a total need of 80-90 lb N 120 P, and 160 K to grow a high yielding carrot crop. Soil test results show medium P levels with 80 lb P2O5 recommended and medium K levels with 120 lb K_2O/acre recommended. The field has 2% organic matter and a pH of 6.5, and there is a stand of red clover that will be turned under about 3 weeks prior to planting. Last summer, 5 tons/acre of dairy manure with bedding were spread after taking the last cutting of hay. Nutrient credits for the soil organic matter, manure, and cover crop appear in Table 8.2.7.

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:	80-90	120	160
2. Recommendations based on soil test	80-90	80	120
3. Credits			
a. Soil organic matter 3%	60	-	-
b. Manure – 5 ton dairy	10	15	45
c. Compost - none	0	0	0
d. Cover crop – red clover	50	0	0
4. Total credits:	120	15	45
5. Additional needed (2-4) =	0	65	75

Table 8.2.3 indicates about 10 lbs. of N will be released in the first season from the 5 tons of dairy manure (N1). Estimate that each percent of organic matter in the soil will release about 20 lbs of N, so the 3% organic matter will supply 60 lbs N (line 3a). Looking at Table 3.1, the red clover cover crop will release about half its fixed N, or 50 lbs as it decomposes (line 3d). With all these sources of N, no additional N is needed in this example, so composts or bagged formulated fertilizers that contain N are not good options for supplying the needed P and K. Applying 800 lbs. of rock phosphate would meet the P requirement. Either potassium sulfate (150 lb) or Sul-Po-Mag (350 lb.) could be used to supply the K.

Additional Resources
Using Organic Nutrient Sources (reference 19a)
Determining Nutrient Applications for Organic Vegetables (reference 19b)

9. HARVESTING AND STORAGE

9.1 Harvest

Machine harvesters are used for the processing crop. It is important to maintain healthy carrot tops so the harvester can pull up the roots.

9.2 Storage

Carrots can be stored for several months at 32°F at 90-95% relative humidity. If the temperature is allowed to rise, sprouting will occur. If the relative humidity is too low, the roots will desiccate.

Carrots may be stored in the field only if excellent soil conditions exist. A well-drained, deep, friable soil full of a diverse mixture of beneficial microbes can provide an environment where pathogens are less likely to cause damage especially if the field has a history of being clear of potential carrot pathogens.

9.3 Microbial Food Safety

Attention to microbial food safety is important for crops that are eaten raw. Continuing produce-associated foodborne illness outbreaks have resulted in many buyers requiring the implementation of food safety practices on the farm and the development of the first ever produce safety regulations as part of the Food Safety Modernization Act (FSMA). Pathogens can contaminate food during all phases of production, harvesting, and packing. Wild and domesticated animals, manure, irrigation water, inadequate worker hygiene, unclean picking containers, unsanitized post-harvest water, and unclean packaging materials are all potential vectors of microbiological contaminants. Growers should conduct a risk assessment to identify microbial hazards and then implement appropriate practices to reduce risks. There are many resources available to help including those at the National GAPs Program (reference 58) or the Produce Safety Alliance (reference 59). Regardless of farm size, commodities or cultural practices, Good Agricultural Practices can be used to identify and possibly reduce microbial risks.

Implementing just a few simple practices can reduce risks significantly. One of these is to wash hands prior to any contact with the crop using potable water and sanitizer, particularly after using the restroom or eating. Do not allow workers who are ill to handle produce. If they are able to work, assign jobs that do not involve contact with produce or customers. Prevent animals or animal manure from contacting produce, by discouraging animals (including pets) from entering production fields and by not using irrigation water that may have been contaminated with manure. Manure must be properly composted or applied well in advance of harvesting a fresh market crop such as lettuce, but check with your certifier or marketer for separate restrictions for manure use on lettuce. Ensure that picking containers are clean and free from animal droppings. Following these steps can dramatically reduce risks of pathogen contamination. Conduct a full assessment of your farm to identify other high risk practices.

The Food Safety Modernization Act (FSMA) will apply to farms that grow, harvest, pack or hold most fruits and vegetables when those fruits and vegetables are in an unprocessed state, and will govern practices affecting: water, worker hygiene, manure and other soil additions, animals in the growing area, and equipment, tools and buildings When the FSMA is finalized, the Food and Drug Administration (FDA) will be mandated to enforce preventive control measures, and to conduct inspections across the food supply system. Updates and information on this proposed rule are available at the United States Food and Drug Administration's Food Safety Modernization Act webpage.

At the time this guide was produced, the following materials were available in New York State as sanitizers 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 9.3.1 Rates for Sanitizers for Postharvest Carrots 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	-
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
Shield-Brite PAA 5.0	1.6fl oz/5 gal water	1.6fl oz/5 gal water	59.1 to 209.5 fl. oz./1,000 gal water	59.1 to 209.5 fl. oz./1,000 gal water
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/1 gal water	0.5 fl oz/1 gal water	1:220 – 1:1,000 dilution (on process/packing	

Table 9.3.1 Rates for Sanitizers for Postharvest Carrots 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**
			line); .035-0.58 fl. oz./gal water (post-harvest spray treatment)	
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 (processing 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. 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.

10.1 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

Calibrating Backpack Sprayers (Link 46).
Cornell Integrated Crop and Pest Management Guidelines (Link 47).
Pesticide Environmental Stewardship: Calibration (Link 48)
.
Knapsack Sprayers – General Guidelines for Use (Link 49)
Herbicide Application Using a Knapsack Sprayer (Link 50. This publication is relevant for non-herbicide applications).
Pesticide Environmental Stewardship, Coop Extension ((reference 51)
Pesticide Environmental Stewardship, CIPM website (reference 52)
Vegetable Spraying (reference 53)

10.2 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 (Link 2) 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 (Link 54). The Organic Materials Review Institute (OMRI) (Link 3) 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 (Link 55). See Revisions To the Worker Protection Standard for a summary of new worker protection standards that will take effect January 2017 (Link 55a) Find more information on pesticide applicator certification from the list of State Pesticide Regulatory Agencies (Link 56) or, in New York State, see the Cornell Pesticide Management Education Program website at http://psep.cce.cornell.edu.

10.3 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

10.4 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. The Resource Guide for Organic Insect and Disease Management (Reference 1) provides 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 (Link 3). 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.

11. 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 Section 6: *Varieties*). Plant only clean, disease-free seed and maintain the best growing conditions possible.

Rotation is an important management practice for pathogens that overwinter 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* diseases, and root-knot nematode. Rotation with a grain crop, preferably a crop or crops that will be in place for one or more seasons, deprives most 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, including the lesion nematode. See more on crop rotation in Section 4.2: *Crop Rotation Plan.*

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, fog, or dew should be avoided if possible.

Scouting fields weekly is key to early detection and evaluating control measures. The earlier a disease is detected, the more likely it can be suppressed with organic fungicides. When available, scouting protocols can be found in the sections listed below for each individual disease. While following a systematic scouting plan, keep watch for other disease problems. Removing infected plants during scouting is possible on a small operation. 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 that could affect yield and be ready to take control action as soon as symptoms are seen. Allowing pathogen populations to build can quickly lead to a situation where there are few or no options for control.

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. They have no activity on pathogens once they are inside the plant. A few fungicides induce plant resistance and must be applied several days in advance of infection to be effective. Biological products must be handled carefully to keep the microbes alive. Follow label instructions carefully to achieve the best results.

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 10. *Using Organic Pesticides* for details. **ALWAYS check with your organic farm certifier when planning pesticide applications**.

Resources:

Cornell Vegetable MD Online (Link 26).

Resource Guide for Organic Insect and Disease Management (Reference 1). Although carrots are not specifically covered in this guide, it contains useful information on how various materials work to manage pests.

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 10.1 Pesticides for Organic Carrot Disease Management

Class of Compound Product name *Active Ingredient*	Cavity Spot	Leaf Blights			Rhizoctonia	White Mold	Seed Decay
		Alternaria Leaf Blight	Cercospora Leaf Blight	Bacterial Leaf Blight			
MICROBIALS							
Actinovate AG (*Streptomyces lydicus WYEC 108)*	X	X			X	X	X
Actinovate STP Fungicide *(Streptomyces lydicus WYEC 108)*					X		X
BIO-TAM (*Trichoderma asperellum, Trichoderma gamsii)*	X				X	X	X
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii)*	X				X	X	X
Contans WG (*Coniothyrium minitans CON/M/91-08)*						1	
Double Nickel 55 Biofungicide *(Bacillus amyloliquefaciens str. D747)*	X			X	X	X	X
Double Nickel LC Biofungicide *(Bacillus amyloliquefaciens str. D747)*	X			X	X	X	X
Prestop Biofungicide *(Gliocladium catenulatum str. J1446)*	X	X			X		X
Regalia Biofungicide (*Reynoutria sachalinensis)*	X	X		X	X	X	X
RootShield Granules *(Trichoderma harzianum Rifai strain T-22)*	X				X		X
RootShield PLUS+ Granules *(Trichoderma)*	X				X		X
RootShield PLUS+ WP *(Trichoderma)*	X				X		X
Serenade ASO (*Bacillus subtilis str. QST 713)*				3		X	
Serenade MAX (*Bacillus subtilis str. QST 713)*				3		X	
Serenade Opti (*Bacillus subtilis str. QST 713)*				X		X	
Serenade Soil (*Bacillus subtilis str. QST 713)*	X				X		X
SoilGard *(Gliocladium virens str. GL-21)*	X				X		X
OPTIVA *(Bacillus subtilis str. QST 713)*						X	
Taegro Biofungicide (*Bacillus subtilis var. amyloliquefaciens)*					X		X
COPPER							
Badge X2 *(copper oxychloride, copper hydroxide)*		2	2				
Basic Copper 53 *(basic copper sulfate)*			2				
Champ WG (*copper hydroxide)*			2				
ChampION++ (*copper hydroxide*)		2	2				
CS 2005 *(copper sulfate pentahydrate)*		2	2				
Cueva Fungicide Concentrate (*copper octanoate)*		2	2	1			
Nordox 75 WG (*cuprous oxide)*		2	2	1			
Nu-Cop 50DF (*cupric hydroxide)*		2	2				
Nu-Cop HB *(cupric hydroxide)*		X	X				
Nu-Cop 50 WP *(copper hydroxide)*			2				

Class of Compound Product name *Active Ingredient*	Cavity Spot	Leaf Blights			Rhizoctonia	White Mold	Seed Decay
		Alternaria Leaf Blight	Cercospora Leaf Blight	Bacterial Leaf Blight			
OTHER							
Falgro 4L *(gibberellic acid)*		X					
ProGibb *(gibberellic acid)*		X					
GibGro 4LS *(gibberellic acid)*		X					
N-Large *(gibberellic acid)*		X					
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*	X	X	X	X	X		X
PERpose Plus (*hydrogen peroxide/dioxide)*	X	X	X	X	X	X	X
TerraClean 5.0 (*hydrogen dioxide, peroxyacetic acid)*	X				X		X
Trilogy -(*neem oil)*		X	X	X		X	
Zonix Biofungicide *(Rhamnolipid Biosurfactant)*	X						

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, X-may be used against pest and OMRI listed, but efficacy not known.

Active ingredient meets EPA criteria for acute toxicity to bees

11.1 Aster Yellows

The pathogen responsible for this disease is aster yellows phytoplasma, previously known as mycoplasma-like or MLOs.

Time of concern: June through August

Key characteristics: The aster yellow phytoplasma over winters in the body of the adult aster leafhopper, although it may also be transmitted by other species of leafhoppers. The severity of aster yellows and damage to the crop depends on the age of the crop when the infection occurs. The first symptom observed in the field is leaf yellowing. In severely affected plants, the new shoots from the crown are sickly and have a "witch's broom" appearance. Older leaves become purple to red and are easily recognizable in the field. The petioles become twisted and are easily broken-off, making mechanical harvesting difficult. Roots of infected plants exhibit numerous tufts of fine roots (hairy condition). See Cornell symptoms of Aster Yellows (Link 28) or University of Minnesota aster leafhopper fact sheet (Link 29). **For management options, see section 13.1.1 Aster leafhopper.**

11.2 Leaf Blights

Alternaria leaf blight, also known as late blight, *Alternaria dauci;*
Cercospora leaf blight, also known as early blight, *Cercospora carotae;*
Bacterial leaf blight, *Xanthomonas campestris pv. Carotae*

Time for concern: See individual pathogens listed below.

Key characteristics: These pathogens are seed-borne can cause severe blight on carrot leaves and petioles during a prolonged period of wet and warm weather. These leaf blights are listed together here because they sometimes occur together and the techniques used to manage them are similar.

Alternaria (fungus)- dark brown to black irregular spots first appear at the margin of the leaflets. Lesions on the petioles and stems are dark brown and girdle the stems. As the disease progresses, entire leaflets may shrivel and die. Lesions are more prevalent on older foliage. Alternaria is most severe in late August and September. See Cornell symptoms of leaf blights (Link 30).

Cercospora (fungus)- small, circular, tan or gray spots with a dead center first appear along the margins of the leaves causing the leaves to curl. As the lesions increase in number and size, the entire leaflet dies. The fungus attacks younger leaves. Because it develops rapidly in hot and humid weather, it is likely to occur in July and early August. See Cornell symptoms of leaf blights (Link 30).

Bacterial - small yellow areas appear on the leaflets. The centers of the lesions become brown and dry and are often surrounded by a yellow halo. See Reference 2 and Cornell symptoms of leaf blights (Link 30). For additional information on fungal and bacterial leaf blight diseases of carrot and scouting methods, see the Cornell 2005 fact sheet (Link 31), and an older but still useful 1988 factsheet (Link 32).

Management Option	Recommendations for Leaf Blights
Scouting/thresholds	Record the type of leaf blight and severity of infection. No threshold has been established for bacterial blights. Once detected, a spray program should commence immediately. The threshold for fungal blight is 25% infected leaves if effective control products are available.
Resistant varieties	Great differences exist in the tolerance of carrot varieties. See Table 6. 1 Recommended Varieties. See also Cornell's carrot disease resistant varieties (Link 26).
Crop rotation	Crop rotation is a very important management tool for fungal and bacterial leaf blights. A minimum rotation of 2 to 3 years out of carrots is effective against the three diseases.
Soil maintenance	Well-fertilized soil reduces the development of *Alternaria*. A nitrogen application made in mid-August or early September may promote foliage development.
Seed selection/treatment	Plant only vigorous and disease-free seeds. All three diseases can be seed-borne therefore using clean seed stock is critical since there are no available products for seed treatment and few control options for organic growers once the disease is established. Hot water treatment of seeds reduces bacterial leaf blight but can risk seed viability. For instructions see Cornell's Managing Pathogens Inside Seed With Hot Water (Link 35a). See also Cornell's treatments for managing bacterial pathogens in vegetable seeds (Link 35).
Post harvest	Crop debris should be destroyed as soon as possible to remove this source of inoculum for other plantings and to initiate decomposition.
Sanitation	This is not a currently viable management option.

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 11.2 Pesticides for Management of Leaf Blights

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	0	1 or until dry	?	Only labeled for leaf blights caused by Alternaria. The label recommends using a spreader sticker for foliar applications.
Badge X2 (copper hydroxide, copper oxychloride)	0.75-3.57 lb/acre	-	48	2	Labeled for Alternaria and Cercospera leaf blights only. Mixed efficacy results against fungal leaf blights.

Table 11.2 Pesticides for Management of Leaf Blights

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Basic Copper 53 (basic copper sulfate)	1-1.9lb/acre	up to day	48	2	Labeled for Cercospera leaf blight only. Begin sprays as soon as disease is detected and repeat at 7-14 day intervals. Mixed efficacy results against fungal leaf blights.
Champ WG (copper hydroxide)	2 lb/acre	-	48	2	Labeled for Cercospera leaf blight only. Mixed efficacy results against fungal leaf blights.
ChampION++ (copper hydroxide)	0.75-1.5 lb/acre	0	48	2	Labeled for Alternaria and Cercospera leaf blights only.
CS 2005 (copper sulfate pentahydrate)	19.2 oz/acre	0	48	2	See comment for Badge X2.
Cueva Fungicide Concentrate (copper octanoate)	0.5-2 gal/acre	up to day	4	2	Mixed efficacy results against fungal leaf blights. Copper based materials have been shown to be effective against bacterial blight if applied as soon as the first symptoms are seen.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre	0	4	?	Only labeled for bacterial leaf blight.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre	0	4	?	Only labeled for bacterial leaf blight.
Falgro 4L (gibberillic acid)	1-6 fl oz/acre	-	4	?	Delayed leaf senescence may decrease incidence of Alternaria infection. Make first application 4-6 weeks after emergence. Do not make more than 2 applications/ crop cycle.
GibGro 4LS (gibberillic acid)	1-6 fl.oz./acre	-	4	?	Delayed leaf senescence may decrease incidence of Alternaria infection.
N-Large (gibberillic acid)	1-6 fl oz/acre	0	4	?	Maintaining vigorous foliage will reduce incidence of infection by Alternaria. Make first application 4-6 weeks after emergence.
Nordox 75 WG (cuprous oxide)	1.25 – 2.5 lb/acre	-	12	2	Mixed efficacy results against fungal leaf blights. Apply when disease appears and repeat application every 7-14 days. Copper based materials have been shown to be effective against bacterial blight if applied as soon as the first symptoms are seen.
Nu-Cop 50 WP (copper hydroxide)	2 lb/acre	1	24	2	Labeled for Cercospera leaf blight only. Mixed efficacy results against fungal leaf blights. Apply when disease appears and repeat application every 7-14 days.
Nu-Cop 50DF (copper hydroxide)	2 lb/acre	1	48	2	See comment for Nu-Cop 50 WP.
Nu-Cop HB (copper hydroxide)	1 lb/acre	-	48	2	See comment for Nu-Cop 50 WP.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water Curative	0	until dry	?	Apply at first sign of disease. Continue with 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

Table 11.2 Pesticides for Management of Leaf Blights					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 floz/100 gal water Preventative	0	until dry	?	Apply first three treatments using curative rate at 5-day intervals. Reduce to preventative rate after the completion of the third treatment and maintain 5-day spray interval until harvest. Bee Hazard. This product is toxic to bees exposed to direct contact
PERpose Plus (hydrogen peroxide)	1 fl oz/acre Initial/curative 0.25-0.33 fl oz/gal/A Weekly preventative	-	until dry	?	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.
ProGibb LV PLUS (gibberillic acid)	0.5-3 fl oz/acre	0	4	?	Used to delay leaf senescence helping to reduce the incidence of infection by *Alternaria dauci.*
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre	0	4	?	Not labeled for Cercospora leaf blight.
Serenade ASO[1] (*Bacillus subtilis* str. QST 713)	2-6 qt/acre	0	4	3	Only labeled for bacterial leaf blight. Bacillus subtilis not effective in 3/3 trials.
Serenade MAX[1] (*Bacillus subtilis* str. QST 713)	1-3 lb/acre	0	4	3	See comment for Serenade ASO.
Serenade Opti[1] (*Bacillus subtilis* str. QST 713)	14-20 oz/acre	0	4	3	See comment for Serenade ASO.
Trilogy (🐝neem oil)	0.5-1.0% in 25-100 gals water/A	up to day	4	?	Maximum 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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. [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

11.3 Cavity Spot, *Pythium violae; Pythium sulcatum and possibly other species.*

Time for concern: Planting through end of the season

Key characteristics: Elliptical- to irregular-shaped depressed lesions appear across the taproots. Initially lesions are usually less than 1 1/2 inches in diameter at different stages of decay. Symptoms may not be apparent until carrots are approaching marketable size. See Ontario Ministry of Agriculture symptoms of cavity spot (Link 33).

Management Option	Recommendations for Cavity Spot
Scouting/thresholds	Record the occurrence and severity of cavity spot. No thresholds have been established.
Resistant varieties	Information about resistance in currently grown varieties is not available.

Management Option	Recommendations for Cavity Spot
Crop rotation	Minimum three-year rotation out of vegetables and alfalfa. Rotations to cole crops, onions or potato have been shown to be beneficial.
Site selection	Excessive moisture and wet soils favor this disease. Select fields with well-drained, light textured and healthy soils. Planting on raised ridges and breaking compacted zones may also be helpful.
Seed selection/treatment	Plant vigorous, disease-free seed.
Harvest	Mature carrots tend to be more susceptible to this disease therefore if soil conditions are wet, it is important to harvest the carrot crop promptly when mature.
Post harvest and Sanitation	These are not currently viable management options.
Cultural Practices	Some cover crops, such as Sudangrass, rapeseed and mustard, have been reported to suppress Pythium. However, this biofumigant effect is not predictable or consistent and may not work at all under poor conditions. Soils should be warm and have adequate moisture to encourage rapid breakdown of the cover crop when incorporated into the soil. Early incorporation of cover crops is essential to allow enough time for the biofumigant byproducts of the decomposing cover crop to disburse prior to planting. The levels of the active compounds and suppressiveness can vary by season, cover crop variety, maturity at incorporation, soil microbial diversity, and microbe population density. See Section 3.4 for more information on biofumigant cover crops.
Note	Cavity Spot is sometimes a symptom of calcium deficiency.

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 11.3 Pesticides for the Management of Cavity Spot

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 soil drench	0	1 or until dry	?	
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	-	1	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	Soil drench or banded spray at planting.
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 /A Initial/curative soil drench	-	until dry	?	Use as a soil drench at the time of seeding, as well as a periodic drench.
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/acre soil drench	0	4	?	

Table 11.3 Pesticides for the Management of Cavity Spot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
RootShield Granules (*Trichoderma harzianum*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
RootShield PLUS+ Granules (*Trichoderma harzianum, Trichoderma virens*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
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.
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	?	Banded, drench, or in-furrow.
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 drench	up to day	0	?	Soil treatment prior to seeding or transplanting. See label for amount of mixed solution to apply. Soil drench for established plants or seedlings.
Zonix (Rhamnolipid Biosurfactant)	0.5 to 0.8 oz/gal water soil treatment	-	4	?	

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. [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.

11.4 Rhizoctonia - Crown Rot, Foliar Blight, and Crater Rot

(*Rhizoctonia solani* and its sexual state *Thanatephorus cucumeris*).

Time for concern: Planting through the end of the season

Key characteristics:

Crater Rot - Crater rot can be common in New York when conditions are warm and moist, but usually only when carrots are grown in short rotations with other crops that host Rhizoctonia like cabbage, peas, beans, and potatoes. Longer rotations with certain grain crops tend to discourage this disease. Symptoms result from infections of *R. solani* on the main root, often where lateral roots emerge. Under warm, moist conditions, lesions of initial infections continue to enlarge and develop into brown to black sunken cankers. The canker-rotted areas remain dry unless colonized and softened by other soil organisms. The lesions may penetrate several millimeters into the taproot; this distinguishes crater rot from the cavity spot lesions caused by *Pythium* species, which are much shallower. See Ontario Ministry of Agriculture diagnostic photo (Link 34).

Foliar blight and Crown Rot –Crown rot and foliar blight are the same disease expressed on the carrot plant in different locations. Crown rot symptoms first show on the crown of the root, and foliar blight is found on the petioles or near the crown. A thin, white to tan layer of mycelial growth becomes visible on the surface of petioles or crown areas. Small spores are produced on these layers and may be carried away by splashing rain or winds and infect other plant parts and adjoining plants. Crown rot symptoms may also result from infections on the main root, and can develop into brown to black sunken cankers that may penetrate several millimeters into the taproot and petioles. Typical cankers may also appear on the infected areas of the crown. Severely infected plants may die resulting in open spaces. See Ontario Ministry of Agriculture fact sheet on crown rot (Link 34).

Management Option	Recommendations for Rhizoctonia
Scouting/thresholds	Record the occurrence and severity of crown and foliar blight diseases. No thresholds have been established.
Resistant varieties	No resistant varieties are available.
Crop rotation	Rotate out of vegetables, preferably with grain crops.
Plant density	Heavy plant density and narrow row spacing of carrots will increase the severity of these diseases, especially under moist conditions.
Hilling	Excessive hilling of carrots, under moist conditions, will increase disease occurrence.
Seed selection/treatment	Plant vigorous, disease-free seed.
Post harvest	If possible, plow crop debris immediately after harvest to remove this source of inoculum for other plantings and to initiate decomposition.
Site selection	Select well-drained sites with light textured and healthy soils. Planting on raised ridges and breaking compacted zones will also be helpful.
Sanitation	This is not a currently viable management option.
Cultural Practices	Although foliar blight and crown rot caused by *Rhizoctonia solani* have been more frequently observed in recent years, they are a sporadic problem in New York carrot fields. Cultural practices that minimize injury to the root, minimize the amount of soil thrown over the crown and increase soil drainage are recommended.

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 11.4 Pesticides for the Management of Rhizoctonia

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	0	1 or until dry	?	The label recommends use of a spreader sticker for foliar applications. Soil drench or foliar spray.
Actinovate STP (*Streptomyces lydicus*)	4-32 oz/100 lb seed seed treatment	-	1 or until dry	?	
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	-	1	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* strD747)	0.125-1 lb/acre soil treatment	0	4	?	Soil drench or banded spray at planting.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	

Table 11.4 Pesticides for the Management of Rhizoctonia

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl oz/50 gal water soil drench	0	until dry	?	Apply to soil to the point of saturation. Bee Hazard. This product is toxic to bees exposed to direct contact
PERpose Plus (hydrogen peroxide)	1 fl oz/gal water soil drench	-	until dry	?	Apply to saturation on soil.
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/acre soil drench	0	4	?	
RootShield Granules (*Trichoderma harzianum*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
RootShield PLUS+ Granules (*Trichoderma harzianum, Trichoderma virens*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
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.
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 in-furrow treatment	-	0	?	Banded drench in furrow.
Taegro (*Bacillus subtilis*)	3 tsp/gallon/A seed treatment 2.6 oz/100 gal water in-furrow treatment	-	24	?	Soil drench or over furrow at time of planting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment	up to day	0	?	Soil treatment prior to seeding or transplanting. See label for amount of mixed solution to apply.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl oz/ 200 gal water/1000 sq ft soil drench	up to day	0	?	Soil drench for established plants or seedlings.

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. [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.

11.5 Sclerotinia White Mold, *Sclerotinia sclerotiorum, and Sclerotinia minor*

Time for concern: Any growth stage, but especially late in the season and close to harvest.

Key characteristics: Root decay may occur before wilt is visible on aboveground plant parts. A cottony, white mycelium appears on the affected area, especially lower plant parts and roots. On or inside the mycelium are black structures (sclerotia) 1/10 to 2/5 inch wide. See Ontario Ministry of Agriculture white mold symptoms (Link 36).

Management Option	Recommendations for White Mold
Scouting/thresholds	Record the occurrence and severity of white mold. Determine the need for treatment with Contans WG after harvest to reduce overwintering inoculum.
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.
Sanitation & Postharvest	If possible, deep plowing once per year to bury sclerotia eight to ten inches deep may reduce disease incidence. Plow under crop debris and plant a grain cover crop.
Crop rotation	Rotate away from vegetables for a minimum of three years, longer if possible.
Seed selection/treatment	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 11.5 Pesticides for Control of Sclerotinia White Mold

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	0	1 or until dry	?	Reapply every 7-14 days depending on disease pressure and environmental conditions. Use a spreader sticker. Soil drench or foliar spray.
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*)	2.5-5 lb/acre	-	1	?	
Contans WG (*Coniothyrium minitans*)	1-4 lbs/A if incorporation is within top 2 inches of soil. 3-6 lbs/A if incorporated deeper than 2" soil treatment	-	4	1	Effective in 8/11 trials. This biological fungicide has been tested in some states; however, limited information is available on effectiveness in our region. Apply 3 to 4 months prior to the onset of disease to allow the active agent to reduce inoculum levels in soil. Following application, incorporate to a depth of 1 to 2 inches but do not plow before seeding to prevent untreated sclerotia in lower soil layers from infesting the upper soil level.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre banded seedline treatment	0	4	?	Apply at or immediately following planting (but before plant emergence). Make second application at thinning or cultivation; ensure thorough coverage of lower leaves and surrounding soil surface. Repeat at 10-14 day intervals if conditions promoting disease persist.

Table 11.5 Pesticides for Control of Sclerotinia White Mold

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Double Nickel LC (*Bacillus amyloliquefaciens* strD747)	0.5-4.5 pts/acre Banded seedline treatment	0	4	?	See note on Double Nickel 55.
Optiva (*Bacillus subtilis* str. QST 713)	14-24 oz/acre	0	4	?	Begin application soon after emergence and when conditions are conducive to disease development. Repeat on 7-10 day interval or as needed.
PERpose Plus (hydrogen peroxide)	1 fl oz/gal/A Initial/curative 0.25-0.33 fl oz/gal/A Weekly preventative	-	until dry	?	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.
Regalia (*Reynoutria sachalinensis*)	1-4 qt/acre	0	4	?	Repeat on 7-10 day interval or as needed.
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	?	
Trilogy (neem oil)	0.5-1% in 25-100 gals water/A	Up to day	4	?	Maximum 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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. [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

11.6 Seed Decay, primarily caused by the pathogens *Pythium* spp. and *Rhizoctonia* spp.

Time for concern: Planting

Key characteristics: Seeds may become infected and decayed prior to or shortly after germination

Management Option	Recommendations for Seed Decay
Crop rotation	Rotate out of vegetables and preferably with a grain crop.
Site selection	Plant on well-drained, good structured and healthy soil.
Resistant varieties	No resistant varieties are available.
Seed selection/treatment	Plant vigorous and disease free seed. Seeds can be tested for vigor at a New York State testing lab. Biological seed treatments are available, but their efficacy is untested.

Scouting/thresholds, post harvest, and sanitation	No thresholds have been established. 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 11.6 Pesticides for Management of Seed Decay

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	0	1 or until dry	?	The label recommends use of a spreader sticker for foliar applications. Soil drench or foliar spray.
Actinovate AG (*Streptomyces lydicus* WYEC 108)	2-18 oz/cwt seed In hopper or slurry seed treatment	0	1 or until dry	?	The label recommends use of a spreader sticker for foliar applications.
Actinovate STP (*Streptomyces lydicus*)	4-32 oz/100 lb seed seed treatment	-	1 or until dry	?	
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	-	1	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	Soil drench or banded spray at planting.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl oz/50 gal water soil drench	0	until dry	?	Apply to soil to the point of saturation. Labeled for Rhizoctonia only. Bee Hazard. This product is toxic to bees exposed to direct contact.
PERpose Plus (hydrogen peroxide)	1 fl oz/gal water soil drench	-	until dry	?	Apply to saturation on soil.
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/acre soil drench	0	4	?	
RootShield Granules (*Trichoderma harzianum*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	
RootShield PLUS+ Granules (*Trichoderma harzianum, Trichoderma virens*)	2.5-6 lb/half acre in-furrow treatment	-	0	?	

Table 11.6 Pesticides for Management of Seed Decay					
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.
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	?	Banded, drench, or in-furrow.
Taegro (*Bacillus subtilis*)	3 tsp/gallon seed treatment	-	24	?	
Taegro (Bacillus subtilis)	2.6 oz/100 gal water in-furrow treatment	-	24	?	Soil drench or over furrow at time of planting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment	up to day	0	?	Soil treatment prior to seeding. See label for amount of mixed solution to apply.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl oz/ 200 gal water in 25-100 gal water/acre soil drench	up to day	0	?	Soil drench for established plants or seedlings.

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. [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.

11.7 Storage Rots

Time for concern: Harvest and storage

Key characteristics: Symptoms vary depending on the fungus or bacterium causing the problem.

Management Option	Recommendations for Storage Rots
Resistant varieties	No resistant varieties are available.
Site selection	Rots are usually more severe in poorly drained sites.
Post harvest	Rots are usually more severe in carrots harvested late and poorly handled during harvest. Immediately after digging, remove the damaged roots and place the healthy roots in storage at 32°F and 90 to 95 percent relative humidity.
Sanitation	Storage bins should be cleaned between seasons.
Scouting/thresholds, Crop rotation, and Seed treatment	Currently there are no thresholds or scouting protocols. Crop rotation and seed treatments are not viable management options.

12. NEMATODE MANAGEMENT

12.1 Northern Root-knot Nematode, *Meloidogyne hapla*

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

Key characteristics: When infection occurs early, the carrots can become severely forked and galled on the main root as well as on the fine fibrous roots. Infection later in the season is often restricted to the fine fibrous roots. Severely infected plants are often stunted and found in irregular patches in the field. Note: Forking can also be caused when other soil-borne pathogens such as Pythium spp. prune the root tips during the young seedling stage but in these cases no galls will be present on the main taproot or fine fibrous roots. Nematodes and their egg masses are visible at 10X magnification on galled tissue. See Cornell bulletin on root-knot nematode (Link 37).

Management Option	Recommendations for Nematodes
Scouting/thresholds	Carrots are very sensitive to infection by root-knot nematode and severe yield losses can result from reduced marketability. It is important to know whether or not this nematode is present in the field in order to develop long-term crop rotations and cropping sequences that either reduce the populations in heavily infested fields or minimize their increase in fields that have no to low infestation levels. Record the occurrence and severity of root-knot nematodes. The damage threshold is less than one egg per cubic centimeter (cc) of soil. 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 (Link 38). See Section 4: Field Selection for more information as well as the following Cornell publications for instructions: Soil Sampling for Plant Parasitic Nematode Assessment (Link 39). Visual Assessment of Root-Knot Nematode Soil Infestation Levels Using a lettuce Bioassay (Link 40). A Soil Bioassay for the Visual Assessment of Soil Infestations of Lesion Nematode (Link 41).
Resistant varieties	No resistant varieties are available.
Crop rotation	Root-knot nematode has a wide host range including carrots and many other vegetable and forage crops such as onion, lettuce, potato, alfalfa, soybean and clover. Grain crops including corn, wheat, barley and oat are non-hosts and are effective at reducing root-knot nematode populations. Root-lesion nematode, Pratylenchus penetrans, damage to carrots is limited and has not been well documented.
Cover Crops	Winter 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 may be effective in reducing both root-knot nematode populations and lesion nematodes in soil populations. Many biofumigant crops will increase root-lesion nematode populations until they are incorporated into the soil as a green manure. Research has suggested that Sudan grass hybrid 'Trudan 8' can be used effectively as a biofumigant to reduce nematode populations and might contribute to a reduction in Cavity Spot (Pythium Violae: Pythium spp.). See section 3: Cover Crops for more information.
Sanitation	Avoid moving soil from infested fields to un-infested fields via equipment and vehicles, etc. Wash equipment after use in infested fields. Limit /avoid surface run-off from infested fields.
Site selection and Post harvest	If possible, plow under crop debris and plant a grain cover crop. Assay soil for nematode infestation if needed.

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 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 soil treatment	-	4	?	
Ecozin Plus 1.2% ME (azadirachtin)	25-56 oz/acre soil drench	0	4	?	
MeloCon (Paecilomyces lilacinus str. 251)	2-4 lb/acre soil treatment	-	4	?	

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. [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

13. 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, and a familiarity with the effectiveness of allowable control practices, 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 and 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 the 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 by avoiding use of broad-spectrum insecticides during periods when natural enemies are present. In most cases, a variety of natural enemies are present in the field, each helping to reduce 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 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 a buildup of pests quickly enough to keep pest 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 5) and A Guide to Natural Enemies in North America (Link 42).

Regulatory

Organic farms must comply with all other regulations regarding pesticide applications. See Section 10 for details. ALWAYS check with your organic farm certifier when planning pesticide applications.

Efficacy

In general, insecticides allowed for organic production kill a smaller percentage of the pest population and have a shorter residual than non-organic insecticides. University-based efficacy testing is not available for many organic pesticides. See Section 10.3 for more information on application techniques that can optimize effectiveness.

Resources:

Natural Enemies of Vegetable Insect Pests(Reference 5).

Biological Control: A Guide to Natural Enemies in North America (Link 42).

Resource Guide for Organic Insect and Disease Management (Reference 1).

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 13 Pesticides for Insect Control in Organic Carrot

Products	Aster Leafhopper	Aphid	Carrot Rust Fly	Carrot Weevil
BOTANICALS				
Aza-Direct (🐝*azadirachtin*)	X	X	X	X
AzaGuard (🐝*azadirachtin*)	X	X	X	X
AzaMax (🐝*azadirachtin*)	X	X	X	X
AzaSol (🐝*azadirachtin*)		X	X	X
Azatrol EC (🐝*azadirachtin*)	X	X	X	X
Azera (🐝*azadirachtin and* 🐝*pyrethrins*)	X	X		X
Ecozin Plus 1.2 % ME (🐝*azadirachtin*)	X	X	X	X
BioLink Insect Repellant (*garlic juice*)	X	X	X	X
BioLink Insect & Bird Repellant (*garlic juice*)	X	X	X	X
Envirepel 20 (*garlic juice*)	X	X		X
Garlic Barrier AG+ (*garlic juice*)	X		X	X
Grandevo (*Chromobacterium subtsugae str. PRAA4-1*)		X		
Molt-X (🐝*azadirachtin*)	X	X	X	X
Neemix 4.5 (🐝*azadirachtin*)	X	X	X	X
Pyganic EC 5.0 (🐝*pyrethrins*)	X	X	X	X
Pyganic EC 1.4 (🐝*pyrethrins*)	X	X	X	X
Trilogy (🐝*neem oil*)		X		
OILS				
BioRepel (*garlic oil*)	X	X		
Cedar Gard (*cedar oil*)	X			
GC-Mite (*cottonseed, corn, and garlic oils*)		X		
GrasRoots (*cinnamon oil*)		X		
Oleotrol-I (*soybean oil*)		X		
Organocide 3-in-1 (*sesame oil*)		X		
OTHER				
M-Pede (*potassium salts of fatty acids*)	X	X		
Nuke Em (*citric acid*)		X		
Sil-Matrix (*potassium silicate*)		X		
Surround WP Crop Protectant (*kaolin*)	X			

X- may be used against pest and OMRI listed

🐝Active ingredient meets EPA criteria for acute toxicity to bees

13.1 MANAGEMENT OF MAJOR INSECT PESTS

13.1.1 Aster Leafhopper, *Macrosteles quadrilineatus*, transmits the pathogen for carrot yellows disease

Time for concern: June through August

Key characteristics: The adult aster leafhopper is about 3/16 inch long and pale green with six black spots on the front of its head. Nymphs resemble adults but are smaller and lack wings. The aster leafhopper transmits the pathogen for aster yellows disease. Symptoms of aster yellows include yellowing of leaves in the center of the crown. New shoots are sickly and appear like a "witch's broom." Older leaves take on red and/or white coloration. Roots may be altered in color and flavor and exhibit a symptom called "hairy root." See University of Minnesota fact sheet (Link 29).

Management Options	Recommendations for Aster Leafhopper
Site Selection and Crop Rotation	Avoid planting near other aster yellows host crops such as anise, broccoli, cabbage, carrot, cauliflower, celeriac, celery, chicory, dandelion, dill, endive, escarole, lettuce, white mustard, New Zealand spinach, onion, parsley, parsnip, potato, pumpkin, radish, salsify, shallot, spinach, squash, and tomato. Leafhoppers migrate from grain fields, so plant as far away from grains as possible.
Resistant varieties	Cultivars vary in susceptibility to aster yellows. Table 6.1 indicates resistance of some varieties to aster yellows. Also see Reference 4.
Natural enemies	Natural enemies may help to control aster leafhopper populations. However, they are not likely to affect transmission of aster yellows. Use Reference 5 for identification of natural enemies.
Scouting/thresholds	Leafhopper feeding does not cause economic damage, but leafhoppers can transmit aster yellows. Record the occurrence and severity of aster leafhoppers, using yellow sticky cards which are good for especially rapid increases in infestations, or sweep nets. Perform 20 sweeps in 5 locations/field and record the total number of leafhoppers present. The University of Wisconsin developed an Aster Yellows Index (AYI) that recommends when to treat for leafhoppers by estimating the relative threat of transmission of aster yellows. The AYI is calculated by multiplying the number of leafhoppers found in 100 sweeps times the percent of local leafhoppers known to be infected with aster yellows. See Reference 4. The AYI (treatment threshold) is 100 for resistant varieties, 75 for intermediate varieties and 50 for susceptible varieties. Varieties that are more resistant to the disease can withstand much higher leafhopper populations. Because it takes a month for yellows symptoms to develop, control measures for aster leafhoppers can be discontinued one month before harvest.
Cultural Control	Eradicate perennial weeds that commonly serve as overwintering hosts of aster yellows including: thistles, plantains, wild carrot, wild chicory, dandelion, fleabanes, wild lettuce, daisies, black-eyed Susan, rough cinquefoil, and many others. Maintain good control of host weeds during the season.
Post harvest	Crop debris should be destroyed as soon as possible to remove this source of disease for other plantings and to initiate decomposition.
Sanitation	This is not a viable management options.
Note(s)	The younger the plant at the time of infection, the more severe the damage from aster yellows. Sowing seed at higher densities can reduce leafhopper numbers and incidence of yellows.

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 13.1.1 Pesticides for Management of Aster 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	?	Control of nymphs only; apply early and often for best control.
AzaGuard (🐝azadirachtin)	10-16 fl oz/acre	0	4	?	Use with a crop oil.
AzaMax (🐝azadirachtin)	1.33 fl.oz/1000 sq ft	0	4	?	
Azera (🐝azadirachtin, 🐝pyrethrins)	1-3.5 pts/acre	-	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
BioRepel (garlic oil)	1 part product: 100 parts water	-	-	?	25(b) pesticide
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME (🐝azadirachtin)	15-30 oz/acre	0	4	?	
Envirepel 20 (garlic juice)	10-32 oz/acre	-	-	?	25(b) pesticide
Garlic Barrier AG (garlic juice)	See comments.	-	-	?	25(b) pesticide. See label for specific information.
Molt-X (🐝azadirachtin)	10 oz/acre	0	4	?	
M-Pede (insecticidal soap)	1 –2% volume to volume	0	12	?	
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	-	12	?	
Surround WP (kaolin clay)	25-50 lb/acre	up to day	4	?	Suppression only. Apply every 7-14 days.

PHI = pre-harvest interval, REI = re-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.

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13.2 MANAGEMENT OF MINOR INSECT PESTS

13.2.1 Aphids, Primarily the Green Peach Aphid, *Myzus persicae*

Time for concern: June through August. Not generally a problem in carrots in New York.

Key characteristics: Adults vary in color. Aphids are generally about 1/16 inch long. Aphid infestations usually occur on new growth causing yellowing or wilting foliage. See pictures of the lifecycle (Link 43).

Management Option	Recommendations for Green Peach Aphid
Scouting/thresholds	When aphids appear in sweep nets, randomly sample 50 plants in the field to determine the percentage of plants infested. Check the newest leaves for the presence of aphids.
Resistant varieties	No resistant varieties are available.
Natural enemies	Natural enemies are helpful in controlling aphid populations. Use Natural Enemies of Vegetable Insect Pests (reference 5) for identification of natural enemies.
Crop rotation, Site selection, Post harvest, and Sanitation	These are not currently viable management options.
Note(s)	Aphid populations decline rapidly during periods of heavy rainfall.

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 13.2.1 Pesticides for the Management of Green Peach Aphid

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 4/7 trials against green peach aphid and in 3/4 trials against other aphids.
AzaGuard (azadirachtin)	10-16 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.
AzaSol (azadirachtin)	6 oz/acre	-	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. Repellant
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellant
BioRepel (garlic oil)	1 part product: 100 parts water	-	-	?	25(b) pesticide
DES-X (insecticidal soap)	2% solution sprayed at 75-200 gallons/acre	0	12	?	
Ecotec (Rosemary oil, Peppermint oil)	1-4 pts/acre	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME	15-30 oz/acre	0	4	1	See comment for Aza-Direct.

Table 13.2.1 Pesticides for the Management of Green Peach Aphid

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
(azadirachtin)					
Envirepel 20 (garlic juice)		-	-	?	25(b) pesticide. Repellant.
GC-Mite (garlic oil, clove oil, cottonseed oil)	1 gal/ 100 gal spray water	-	-	?	25(b) pesticide. Spray to cover surface.
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.
M-Pede (insecticidal soap)	1 –2% volume to volume	0	12	3	Soap-based products not effective in 9/9 trials against green peach aphid. If using to control green peach aphid, must tank mix with a properly labeled companion insecticide. Soap- based products effective in 6/8 trials against aphids other than green peach aphid.
Neemix 4.5 (azadirachtin)	5-7 fl.oz./acre	0	4	1	See comment for Aza-Direct.
Nuke Em (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)	43-45 fl.oz./100 gal water	-	-	?	25(b) pesticide
Organocide (sesame oil)	1-2 gal/100 gal water /acre	-	-	?	25(b) pesticide
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	Pyrethrum based products effective in 1/3 trials.
Sil-Matrix (potassium silicate)	0.5-1% solution	0	4	?	
Trilogy (neem oil)	0.5-1%	up to day	4	?	Bee Hazard. This product is toxic to bees exposed to direct contact.

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. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

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13.2.2 Carrot Rust Fly, *Psila rosae (Fabricius)*

Time for concern: mid-May until harvest

Key characteristics: Adults are 6 mm long, slender, shiny and black and have red heads and long yellow legs. Eggs are laid on the ground. Young larvae burrow into the soil and initially feed on root hairs and rootlets, whereas older larvae typically tunnel within the lower one-third of the root. Larvae may kill young plants and injury to older plants may allow entry by pathogens that will cause roots to rot. There are 2 to 3 generations per year. This is an uncommon pest in New York. See Cornell fact sheet (Link 44).

Management Option	Recommendations for Carrot Rust Fly
Scouting/thresholds	Flies are monitored using yellow sticky traps. Traps should be placed just above the carrot canopy and within the first couple of rows along the field edges. Fields that are sheltered by woods are often at higher risk than those that are in open areas. Damage is often most prevalent along field edges. There should be an average of 2.5 to 5 sticky traps per acre. Traps should be monitored 1 to 2 times per week. The action threshold is 0.1 flies/trap/day. Spray in the early evening when flies are in the field. Spraying to control flies is not necessary within one month of harvest because it takes at least one month for larvae to enter roots after eggs are laid.
Resistant varieties	No resistant varieties are available.
Natural enemies	Little is known about the effect of natural enemies on carrot rust flies.
Planting date	Carrots seeded after mid-May may avoid serious injury by carrot rust fly.
Crop Rotation	Crop rotation is effective as long as fields are rotated at least 1 mile away from previous year's carrot fields.
Site selection, Post harvest, and Sanitation	Select fields that are not sheltered by trees or tend to be very humid. Damage is often most prevalent along field edges. Do not plant near fields that had high infestations of carrot rust flies the previous season. The number of overwintering flies will be reduced if crop debris is removed after harvest.

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 13.2.2 Pesticides for the Management of Carrot Rust Fly

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	?	Soil drench or foliar spray.
AzaGuard (azadirachtin)	10-16 oz/acre	0	4	?	Use with a crop oil. Soil drench or foliar spray.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	?	
AzaSol (azadirachtin)	6 oz/acre	-	4	?	Soil drench or foliar spray.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/1000 sq ft	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
Ecozin Plus 1.2% ME	15-30 oz/acre	0	4	?	Soil drench or foliar spray.

Table 13.2.2 Pesticides for the Management of Carrot Rust Fly					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2](Days)	REI (Hours)	Efficacy	Comments
(azadirachtin)					
Garlic Barrier AG (garlic juice)	See comments.	-	-	?	25(b) pesticide See label for specific information.
Molt-X (azadirachtin)	10 oz/acre	0	4	?	
Neemix 4.5 (azadirachtin)	7-16 oz/acre	0	4	?	
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	?	

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. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.
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13.2.3 Carrot Weevil, Listronotus oregonensis (Le Conte)

Time for concern: mid-May until harvest

Key characteristics: Adults are dark-brown, snout-nosed beetles that are about 6 mm long. Adults lay 2-3 eggs in the petioles or crown of the carrots beginning in the first true leaf stage. Eggs hatch in one to two weeks and white, grub-like larvae either tunnel down into the root or leave the stalk and bore into the side of the root from beneath the soil. Larvae may kill young plants. Damage to older plants is typically observed in the upper one-third of the root. Feeding injury may allow entry by pathogens that will cause roots to rot. There are 2 generations per year. This is an uncommon pest in New York. See carrot weevil damage and photo of scouting method in Cornell's slideshow. (Link 45 beginning on slide 9).

Management Option	Recommendations for Carrot Weevil
Scouting/thresholds	Weevils are monitored by taking 2 to 4 inch sections of mature carrot roots and placing them vertically in the soil between rows. Five to 10 groups of 5 root sections are positioned within the first several rows along the field's edges. The presence of adults is determined by monitoring oviposition punctures made in the root pieces. The action threshold is 0.3 punctures per root-piece per day, or over 25% of the root pieces with punctures. Apply one or two sprays 10-14 days apart when most adults have left their overwintering site but before they start laying eggs.
Resistant varieties	No resistant varieties are available.
Natural enemies	Natural enemies will feed on carrot weevil eggs, larvae and occasionally adults. Minimizing use of insecticides will help preserve populations of natural enemies.
Crop Rotation	Crop rotation is quite effective because adults rarely fly. Fields should be rotated as far away as possible from previous year's carrot fields (at least 0.5 to l mile away). Rotate with non-umbelliferous plants whenever possible.
Site selection, Postharvest, and Sanitation	Remove crop debris after harvest to remove food source and reduce carrot weevil's ability to overwinter. Crop debris may also serve as a host early the following spring.

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 13.2.3 Pesticides for the Management of Carrot Weevil

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	?	Soil drench or foliar spray.
AzaGuard (azadirachtin)	10-16 oz/acre	0	4	?	Use with a crop oil. Soil drench or foliar spray.
AzaMax (azadirachtin)	1.33 fl.oz/1000 sq ft	0	4	?	
AzaSol (azadirachtin)	6 oz/acre	-	4	?	Soil drench or foliar spray.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	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
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	?	Soil drench or foliar spray.
Envirepel 20 (garlic juice)	10-32 oz/acre	-	-	?	25(b) pesticide
Garlic Barrier AG (garlic juice)	See comments	-	-	?	25(b) pesticide. See label for specific information.
Molt-X (azadirachtin)	10 oz/acre	0	4	?	
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	-	12	?	

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. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

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14. PESTICIDES AND ABBREVIATIONS MENTIONED IN THIS PUBLICATION

Table 13.1. Insecticides mentioned in this publication

TRADE NAME	COMMON NAME	EPA REG. NO.
Aza-Direct	*azadirachtin*	71908-1-10163
AzaGuard	*azadiracthin*	70299-17
AzaMax	*azadiracthin*	71908-1-81268
AzaSol	*azadirachtin*	81899-4
Azatrol EC	*azadirachtin*	2217-836
Azera	*azadirachtin and pyrethrins*	1021-1872
BioLink Insect Repellant	*garlic juice*	exempt-25(b)
BioLink Insect & Bird Repellant	*garlic juice*	exempt-25(b)

Table 13.1. Insecticides mentioned in this publication

TRADE NAME	COMMON NAME	EPA REG. NO.
BioRepel	*garlic oil*	exempt-25(b)
Cedar Gard	*cedar oil*	exempt-25(b)
DES-X	*insecticidal soap*	67702-22-70051
Ecotec	*rosemary and peppermint oil*	exempt-25(b)
Ecozin Plus 1.2 % ME	*azadirachtin*	5481-559
Envirepel 20	*garlic juice*	exempt-25(b)
Garlic Barrier AG+	*garlic juice*	exempt-25(b)
GC-Mite	*cottonseed, clove and garlic oil*	exempt-25(b)
Grandevo	*Chromobacterium subtsugae str. PRAA4-1*	84059-17
GrasRoots (	*cinnamon oil*	exempt-25(b)
Molt-X	*azadirachtin*	68539-11
M-Pede	*potassium salts of fatty acids*	10163-324
Neemix 4.5	*azadirachtin*	70051-9
Nuke Em	*citric acid*	exempt-25(b)
Oleotrol-I	*soybean oil*	exempt-25(b)
Organocide 3-in-1 Garden Spray	*sesame oil*	exempt-25(b)
Pyganic EC 1.4	*pyrethrin*	1021-1771
Pyganic EC 5.0	*pyrethrin*	1021-1772
Sil-Matrix	*potassium silicate*	82100-1
Surround WP Crop Protectant	*kaolin*	61842-18
Trilogy	*neem oil*	70051-2

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Table 13.2 Fungicides mentioned in this publication

TRADE NAME	COMMON NAME	EPA REG. NO.
Actinovate AG	*Streptomyces lydicus WYEC 108*	73314-1
Actinovate STP Fungicide	*Streptomyces lydicus WYEC 108*	73314-4
Badge X2	*copper oxychloride, copper hydroxide*	80289-12
Basic Copper 53	*basic 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
ChampION++	*copper hydroxide*	55146-115
Contans WG	*Coniothyrium minitans*	72444-1
CS 2005	*copper sulfate pentahydrate*	66675-3
Cueva Fungicide Concentrate	*copper octanoate*	67702-2-70051
Double Nickel 55 Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-108
Double Nickel LC Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-107
Falgro 4L	*gibberillic acid*	62097-2-82917
GibGro 4LS	*gibberillic acid*	55146-62
N-Large	*Gibberellic acid*	57538-18
Nordox 75 WG	*cuprous oxide*	48142-4
Nu-Cop 50DF	*cupric hydroxide*	45002-4

Table 13.2 Fungicides mentioned in this publication

TRADE NAME	COMMON NAME	EPA REG. NO.
Nu-Cop 50 WP	*cupric hydroxide*	45002-7
Nu-Cop HB	*cupric hydroxide*	42750-132
Optiva	*Bacillus subtilis str. QST 713*	69592-26
OxiDate 2.0	*hydrogen dioxide, peroxyacetic acid*	70299-12
PERpose Plus	*hydrogen peroxide/dioxide*	86729-1
Prestop	*Gliocladium catenulatum str. J1446*	64137-11
ProGibb	*gibberillic acid*	73049-498
Regalia Biofungicide	*Reynoutria sachalinensis*	84059-3
RootShield Granules	*Trichoderma harzianum Rifai strain T-22*	68539-3
RootShield PLUS+ Granules	*Trichoderma species*	68539-10
RootShield PLUS+ WP	*Trichoderma species*	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
SoilGard	*Gliocladium virens str. GL-21*	70051-3
Taegro Biofungicide	*Bacillus subtilis*	70127-5
TerraClean 5.0	*hydrogen dioxide, peroxyacetic acid*	70299-13
Trilogy	🐝*neem oil*	70051-2
Zonix Biofungicide	*Rhamnolipid Biosurfactant*	72431-1

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Table 13.3 Nematicides mentioned in this publication

TRADE NAME	COMMON NAME	EPA REG. NO.
DiTera	*Myrothecium verrucaria*	73049-67
Ecozin Plus 1.2 % ME	🐝*azadirachtin*	5481-559
MeloCon	*Paecilomyces lilacinus str. 251*	72444-2

🐝Active ingredient meets EPA criteria for acute toxicity to bees

Table 13.4 Sanitizers mentioned in this publication

TRADE NAME	COMMON NAME	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'	*Peroxy acetic acid/hydrogen peroxide*	63838-1
Per-Ox	*Peroxy acetic acid/hydrogen peroxide*	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
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	NE	not effective
AG	agricultural use label	NI	no information
AR	annual rye	NFT	not frost tolerant
ASO	aqueous suspension-organic	P	phosphorus
AS	aqueous suspension	PHI	pre-harvest interval
DF	dry flowable	P_2O_5	phosphorus oxide
EC	emulsifiable concentrate	PR	perennial rye
F	flowable	R	resistant varieties
HC	high concentrate	REI	restricted-entry interval
K	potassium	WP	wettable powder
K_2O	potassium oxide	WG	water dispersible granular
N	nitrogen	WPS	Worker Protection Standard

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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 133. June 2016. www.nysipm.cornell.edu.