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Organic Production and IPM Guide for Lettuce

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2016 Production Guide for
Organic Lettuce

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INTRODUCTION

This guide for organic production of lettuce 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 production of baby lettuce greens and greens in greenhouses require slightly different techniques which are generally not addressed in this guide.

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

Lettuce is grown for its edible leaves as a salad crop. It may be the most widely grown crop on organic farms because its value as "locally produced" is unsurpassed. There are three commonly grown types of lettuce: leaf, head (crisphead, bibb, butter) and romaine (cos). All three are popular as baby salad greens and are used in salad mixes. Cultivated lettuce is closely related to wild lettuce and both share the same insect pests and diseases.

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.

Key Pests of Lettuce. Perennial pests in NY

Diseases	Insects
Gray mold	Aphids
Bottom rot	Tarnished plant bug
Downy mildew	

Potentially Serious Pests. Use management strategies to prevent buildup of this potentially serious pest.

Sclerotinia drop

1. General Organic Management Practices

1.1 Organic Certification

To use a certified organic label, farming operations grossing more than $5,000 per year in organic products must be certified by a U.S. Department of Agriculture National Organic Program (NOP) accredited certifying agency. The choice of certifier may be dictated by the processor or by the target market. A list of accredited certifiers (reference 14) operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Development/Assistance webpage (reference 15). 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 foundation of organic farming. Regular additions of organic matter in the form of cover crops, compost, or manure create a soil that is biologically active, with good structure and capacity to hold nutrients and water (note that any raw manure applications must occur at least 120 days before harvest). Decomposing plant materials will activate a diverse pool of microbes, including those that break down organic matter into plant-available nutrients, as well as others that compete with plant pathogens in the soil and on the root surface. However, newly incorporated organic matter can reduce germination and increase damping-off in lettuce. Allow 2 weeks between incorporation and planting.

Rotating between crop families can help prevent the buildup of diseases that overwinter in the soil. Rotation with a grain crop, or preferably a crop or crops that will be in place for one or more seasons, deprives many, but not all, disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. The same practices are effective for preventing the buildup of a number of root damaging nematodes in the soil, especially the root-knot nematode, but keep in mind that certain grain crops are also hosts for some nematode species including lesion nematodes. Rotating between crops with late and early season planting dates can reduce the buildup of weed populations. Organic growers must attend to the connection between soil, nutrients, pests, and weeds to succeed. An excellent resource for additional information on soils and soil health is Building Soils for Better Crops by Fred Magdoff and Harold Van Es, 2010 (reference 25). For additional information, refer to the Cornell Soil Health website (reference 26).

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, carefully considering 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 the 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 untreated conventional seed to be used. Suppliers should provide a purity test for cover crop seed. Always inspect the seed for contamination from weed seeds and return if it is not clean. Cover crop seed is a common route for introduction of new weed species onto farms.

3.1 Goals and Timing for Cover Crops

Adding cover crops regularly to the crop rotation plan can result in increased yields of the subsequent cash crop. Goals should be established for choosing a cover crop; for example, the cover crop can add nitrogen, smother weeds, or break a pest cycle. The cover crop might best achieve some of these goals if it is in place for an 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 while avoiding any unwanted allelopathic effects on the next cash crop. Another option is to overlap the cover crop and the cash crop life cycles by overseeding, interseeding or intercropping the cover crop between cash crop rows at final cultivation. An excellent resource for determining the best cover crop for your situation is Northeast Cover Crop Handbook, by Marianne Sarrantonio (reference 22) or the Cornell online decision tool to match goals, season, and cover crop (reference 24).

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

3.2 Legume Cover Crops

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

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

Special considerations for lettuce

Annual field pea is an example of an appropriate legume cover crop for lettuce planted in the early spring or late summer. Under the right conditions, field peas can supply up to ~90 pounds of nitrogen per acre after incorporation. Avoid hairy vetch if lesion nematode is a problem since both hairy vetch and lettuce serve as hosts (reference 23). See more about managing these pests in Section 2: *Soil Health.*

3.3 Non-legume Cover Crops

Barley, rye grain, rye grass, Sudangrass, wheat, oats, and other grain crops left on the surface as dead plant residues, or plowed under in the spring as green manures, are beneficial because these plants take up nitrogen that otherwise might be leached from the soil, and release it back to the soil when as they decompose. If incorporated, allow two weeks or more for decomposition prior to planting.

3.4 Combining Legumes and Non-legumes.

Interseeding a legume with non-legume cover crop combines the benefits of both. An oat and field pea combination is a quick cover crop that can be grown and incorporated in the same season as a lettuce crop. They supply extensive organic matter and nitrogen when incorporated. Growing these cover crops together reduces the overall nitrogen contribution but is offset by the improvement in soil organic matter.

3.5 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 brand 199 and Nemat).

The management of the cover crops should encourage maximum 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 the 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.

Green-chopped Sudangrass, incorporated prior to planting, has been shown to suppress root-knot nematodes and improve lettuce yields. The effect is best when Sudangrass is grown for 1 to 2 months, then incorporated before frost (reference 23).

Reference

Crop Rotations on Organic Farms: A Planning Manual (reference 3).
Northeast Cover Crops Handbook (reference 22).
Cover Crops for Vegetable Production in the Northeast (reference 23).
Cover Crops for Vegetable Growers: Decision Tool (reference 24).

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

Species	Planting Dates	Life Cycle	Cold Hardiness	Heat (Tolerances)	Drought (Tolerances)	Shade (Tolerances)	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
CLOVERS											
Alsike	April-May	Biennial/ Perennial	4	5	5	6	6.3	Clay to silt	4-10	60-119	+Endures waterlogged soils & greater pH range than most clovers
Berseem	Early spring	Summer annual[b]/ Winter ann.	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[b]/ Winter annual	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 summer	Biennial	4	6	7-8	4	6.5-7.5	Most	9-20	90-170	+Deep taproot breaks up compacted soils & recycles nutrients +Good catch crop +High biomass producer
OTHER LEGUMES											
Cowpeas	Late spring-late summer	Summer annual[b]	NFT	9	8	6	5.5-6.5	Sandy loam to loam	25-120	130	+Rapid hot weather growth
Faba 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 ann.	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/ Sum. ann[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 ®,http://www.rodaleinstitute.org/, M. Sarrantonio. 1994. Northeast Cover Crop Handbook (reference 22).

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

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

NI-No Information, NFT-No Frost Tolerance. Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. AR=Annual Rye, PR=Perennial Rye. b Winter killed. Reprinted with permission from Rodale Institute®, www.rodaleinstitute.org, M. Sarrantonio. 1994. Northeast Cover Crop Handbook (reference 22)

4. Field Selection

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

4.1 Certification Requirements

Certifying agencies have requirements that affect field selection. Fields cannot be treated with prohibited products for three years prior to the harvest of a certified organic crop. Adequate buffer zones 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. Buffer zones commonly range between 20 and 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, 14). 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 3: *Cover Crops* and Section 5: *Weeds* for more information.

Rotating crops that produce abundant organic matter, such as hay and grain-legume cover crops, with ones that produce less, such as vegetables, will help to sustain organic matter levels and promote good soil tilth (see Section 2: *Soil Health* and Section 8: *Crop and Soil Nutrient Management*). Lettuce generally has a high nutrient requirement (Table 4.2.1).

Growing a cover crop, preferably one that includes a legume, prior to or after a lettuce crop will help to renew soil nitrogen, improve soil structure, and diversify soil organisms. Include deep rooted crops in the rotation to help break up compacted soil layers.

Table 4.2.1 Crop 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 (reference 3).

Crop rotation information specific to lettuce

Growers are encouraged to rotate lettuce with another crop whenever possible. This aids in the management of many pests that affect lettuce. Double-cropping lettuce on the same field may greatly increase problems such as *Sclerotinia* drop, corky root rot, root-knot nematode, and virus diseases in the second planting. For most diseases, maintaining at least 3 years between lettuce crops is recommended, although heavy infestations of pathogens causing diseases like drop may require longer rotations.

Sclerotinia sclerotiorum (lettuce drop): Broccoli grown prior to lettuce helps to reduce lettuce drop. Rotate away from bean, potato, and pea which are all especially susceptible to *Sclerotinia*.

Rhizoctonia: Highly susceptible crops include beans, lettuce, cabbage, and potato. Rotate away from these crops for at least 3 years. Other host crops include broccoli, kale, radish, turnip, carrot, cress, cucumber, eggplant, pepper, and tomato. Cereal crops are not susceptible and are useful for reducing *Rhizoctonia*.

Colletotrichum coccodes: Lettuce can be a symptomless carrier of the pathogen causing anthracnose in tomato and black dot in potato.

Root-knot Nematode: This nematode feeds on many plants including weeds and cover crops. Nutsedge is a weed particularly prone to root-knot nematode and hairy vetch is a highly susceptible cover crop. Many vegetables also are hosts, therefore rotating with sorghum, small grains, or grasses is recommended. Green-chopped Sudangrass, incorporated prior to planting, has been shown to suppress root-knot nematodes and improve lettuce yields. The effect is best when Sudangrass is grown for 1 to 2 months, then incorporated before frost (reference 23). See Section 3.5: *Biofumigant Cover Crops* for more information.

Multiple plantings: The short growing season for lettuce makes it a good choice for double cropping with longer season crops such as cucurbits, tomato, eggplant, pepper, beet, carrot, or onion. Residues from the lettuce crop act as a green manure for subsequent crops. Growing root crops, such as beets, in rotation with lettuce is common. Fall lettuce can be planted in the same field as spring peas within the same growing season. The lettuce benefits from the elevated nitrogen provided by the pea crop. While multiple plantings of vegetable crops may fit well into the rotation, this practice can increase pest pressures on crops that share susceptibility to the same pathogens and nematodes. Careful planning and monitoring is required when double cropping vegetables in the same season.

Weeds: Growing a short season crop, like lettuce, helps reduce the weed population within a field prior to planting longer season crops which are more prone to weed infestations on organic farms.

Cover crops: Red clover, field peas, bell beans and fava beans host a related *Sclerotinia* disease that can infect lettuce, pea and possibly other plants.

For more details, see Crop Rotation on Organic Farms: A Planning Manual(reference 3)

Table 4.2.2 Potential Interactions of Crops Grown in Rotation with Lettuce

Crops	Potential Rotation Consequences	Comments
Onion, leek, carrot, tomato, eggplant, pepper, cucurbits	Reduced weeds	Alternate growing a short season crop such as lettuce with a long-season crop to break weed cycles and make efficient use of fields. An early season lettuce crop can act as a cover crop for crops planted later in the same season.
Bean, carrot, cabbage, tomato, celery, pea	Increased *Sclerotinia*	*Sclerotinia* has a wide host range including lettuce, bean, carrot, cabbage, tomato, celery, and pea. Rotate away from these crops for 3 years. Instead plant sweet corn or grain crops such as barley, oat, wheat, field corn, or grain cover crops.
Pea, fava bean, bell bean, red clover	Increase *Sclerotinia* of broadbean	*Sclerotinia trifoliorum* can attack a wide range of hosts including lettuce.
Tomato	Increase *Colletotrichum coccodes*	Lettuce, cabbage and cress can be silent carriers of this pathogen that causes tomato anthracnose and black dot in potato.

Excerpt from Appendix 2 of Crop Rotation on Organic Farms: A Planning Manual (reference 3).

4.3 Pest History

Knowledge about the pest history of each field is important for planning a successful cropping strategy. For example, 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* without a rotation of several years with sweet corn or grain crops. Treat with Contans™ to reduce fungal sclerotia in the soil immediately after an infected crop is harvested and/or before planting lettuce.

Lettuce is a favored host for root-knot nematode, *Meloidogyne hapla*, and can also host the root lesion nematode, *Pratylenchus penetrans*, but the degree of damage is not known. Knowing whether or not these nematodes are present aids development of cropping sequences that either reduce the populations in heavily infested fields or minimize their increase in fields that have little to no infestation. Refer to Section 12 for more information on nematodes.

4.4 Soil and Air Drainage

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, creates an environment that favors 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.

5. WEED MANAGEMENT

Weed management can be one of the biggest challenges on organic farms, especially during the transition and the first several years of organic production. To be successful, use an integrated approach to weed management that includes crop rotation, cover cropping, cultivation, and planting design, based on an understanding of the biology and ecology of dominant weed species. A multi-year approach that includes strategies for controlling problem 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.

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

5.1 Record Keeping

Scout and develop a written inventory of weed species and their severity for each field. Accurate identification of weeds is essential. Weed fact sheets provide a good color reference for common weed identification. See Cornell weed ecology and Rutgers weed gallery websites (references 37-38).

5.2 Weed Management Methods

Planting and cultivation equipment should be set up on the same number of rows to minimize crop damage during cultivation. Specialized equipment may be needed to successfully control weeds in some crops. See the resources at the end of this section to help fine-tune your weed management system. Reduce disease pressure by planting lettuce in fields that have been free from weeds that serve as alternate hosts to many lettuce diseases such as dandelion, prickly lettuce, sowthistles, wild sunflower and common groundsel for two to three years.

Heading types of lettuce grown on organic farms should be transplanted to provide them with an advantage over the weeds and to allow for earlier cultivation. See more in Section 7: *Planting*. Information on weed control for baby greens is generally not addressed in this guide.

If weed pressure is high, precede plantings for late summer or fall harvest with a one month cultivated fallow to reduce the weed seed bank. Till early enough to prevent winter annual weeds like chickweed and shepherd's purse from going to seed. Prepare a seed bed by harrowing thoroughly but shallowly at two week intervals until planting time. Use shallow tillage to prepare the final seedbed to avoid bringing new weed seeds to the soil surface. A cultivated fallow will greatly reduce species like pigweed and galinsoga that often plague summer plantings. To minimize damage to the soil caused by leaving the soil surface bare, plan to mow and incorporate a heavy cover crop, for example, rye with hairy vetch, before beginning the fallow. This will leave some small pieces of cover crop residue on the surface to intercept rain drops and create a spongy soil consistency that will absorb rain and avoid crusting. Avoid hairy vetch in fields with a history of lesion nematodes. If planting will be as late as August, include a short term cover crop of buckwheat in the fallow to maintain soil organic matter.

For early cultivations after planting, use vegetable knives on a belly mounted cultivator. Set the knives shallow, 1 to 1.5 inches below the soil surface, with the blades pointed away from the row. Cultivate as closely as possible. Use sweeps or duck foot shovels with at least 25% overlap to clean weeds out of the inter-row areas and loosen soil behind the tractor tires. Cultivate at about 10-day intervals to avoid letting weeds grow larger than 2 inches. To minimize root pruning, set knives to run as shallowly as possible without creating skips. If field preparation has created a highly uniform surface, a cultivation depth of 3/4 to 1 inch is sufficient. Continue cultivating until the crop canopy is too closed to allow tractor traffic or harvest is imminent. Usually two to three cultivations are sufficient, but note that with lettuce, the objective of weed management is not just reduction in competition. Untangling grass leaves and chickweed from lettuce during harvest can add to the cost of labor.

To control weeds between plants in the row, hand hoe once, typically just after the second machine cultivation, but before the biggest weeds are 2 inches tall. The goal is to kill weeds while they are still small. Hoe soon after cultivation since breaking the soil between the rows will ease penetration of the hoe. Use a stirrup hoe (shuffle hoe) pulling toward the plant stalk. Try to throw about 1 inch of soil in around base of the plant to cover small weeds that are too close to the crop plants to cut with the hoe. For maximum effectiveness, keep both the edges and curved shoulders of the stirrup blade sharp. Following the above practices, only one hand hoeing should be required.

Straw or hay mulch is not recommended for lettuce since the sharp ends can damage lettuce leaves and it promotes the buildup of slugs and snails. If using plastic mulch, cultivate along the edges of the mulch with hilling discs or rolling gangs and between the plastic beds with overlapping sweeps. Hand pull larger weeds growing next to the lettuce plants when the crop is 2/3 through its development.

Clean up the field soon after harvest. Lettuce can be an effective component in the overall weed control program on a vegetable farm since it is generally harvested before weeds have time to set seed. It can act as a "cleaning" crop, reducing the seed bank following weed control failures and preceding crops in which weed management is difficult. But to receive these benefits from the lettuce, weeds must be destroyed soon after harvest before they can go to seed.

High soil phosphorus and potassium levels can exacerbate problem weed species. For example, high phosphorus promotes common purslane and high potassium promotes dandelion. See Section 8 for more information on balancing nutrients on organic farms.

Resources

Crop Rotation on Organic Farms: A Planning Manual (reference 3)
Steel in the Field (reference 35)
New Cultivation Tools for Mechanical Weed Control in Vegetables (reference 36)
Cornell Weed Ecology website (reference 37)
New Jersey Weed Gallery (reference 38)
Principles of Sustainable Weed Management for Croplands (reference 39)
Weed "Em and Reap Videos (reference 40)
Flame Weeding for Vegetable Crops (reference 41)
Vegetable Farmers and their Weed-Control Machines (reference 42)
Twelve Steps toward Ecological Weed Management in Organic Vegetables (reference 43)

6. Recommended Varieties

Variety selection is important, both for the horticultural characteristics specified by the market, and the pest resistance profile that will be the foundation of a pest management program. If a field has a known disease history, Table 6.1 can help to determine which varieties will be more successful in reducing disease problems. Consider the market when choosing varieties, selecting those with some level of disease resistance if possible.

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

Table 6.1 Disease Resistance in Lettuce Varieties.

Variety Name (days to harvest)	**Type**	**Bottom Rot**	**Corky Root Rot**	**Downy Mildew**	**Bacterial Spot**	**Lettuce Mosaic Virus**	**Drop**		**Bolting**	**Heat**	**Brown Rib**	**Tip Burn**	**Comments**
BUTTERHEAD and BIBB													
Adriana (48)	Butter			X		X			X	X		X	
Escale	Bibb			X		X			X				
Barracuda	Bibb								X				
Bennett MI (64)	Butter											X	
Buttercrunch (60) [1, 2]	Butter								X				Open pollinated
Ermosa (48) [1, 2]	Butter			X		X			X	X		X	
Esmeralda (68) [1, 2]	Butter			X		X			X			X	
Fireball (51)	Butter									X			
Focea (45)	Butter			X		X							
Harmony (68)	Butter			X					X	X		X	
Kagraner Sommer [2]	Butter								X				
Kweik (55)	Butter			X			X					X	
Lucan				X					X			X	
Margarita (68)	Boston			X		X			X			X	Open pollinated
Nancy (62) [1]	Boston			X		X							Open pollinated
Odyssey MI (62)	Butter								X			X	Open pollinated
Optima (68-70)	Butter	X		X		X			X			X	Open pollinated
Pirat (55) [2]	Butter			X	X		X					X	Heirloom; red tinged.
Rex (50)	Butter			X					X			X	Better for greenhouses.
Speckled [2]	Butter												German heirloom

Table 6.1 Disease Resistance in Lettuce Varieties.

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Summer Bibb (65) [1]	Bibb							X	X		X	For hotbed and greenhouse growing
Summer Long Salad	Mix								X			Looseleaf, romaine, butter combination
Sylvesta (52)	Bibb			X		X						
Tom Thumb (46)	Butter							X	X			Open pollinated
Victoria (45)	Butter							X	X			Open pollinated
Winter Density (60) [2]	Butter/cos							X				Open pollinated
BUTTERHEAD - RED												
Australe (49)	Butter - red			X				X				
Lucan	Butter - red			X				X			X	
Red Cross (48) [2]	Butter - red			X					X			
Roxy (50)	Butter - red			X							X	
CRISPHEAD												
Fallgreen (70)	Crisphead			X		X		X			x	
Great Lakes (70+) [1]	"							X			X	Heirloom
Igloo (70)	"								X			
Ithaca (72-85) [1]	"					X			X	X	X	
Salinas 88 Supreme (50)	"					X						
Santa Fe (55)	"								X			
Summer Time (75)	"							X	X	X	X	Open Pollinated
Sun Devil (60)	"							X	X		X	
LOOSE LEAF - GREEN												
Baby Oakleaf (50)	Oakleaf							X				
Berenice (50)	Oakleaf					X		X	X			
Bergam's Green (57)	Loose		X					X	X		X	
Black Seeded Simpson (44) [2]	Loose			X			X	X	X		X	
Deer Tongue (48)	Loose							X				Heirloom
Emerald (50-54)	Oakleaf										X	
Galisse (48) [2]	Loose			X		X						Sensitive to short daylength
Grand Rapids (45) [1]	Loose								X		X	Open pollinated
Green Bay (48)	Loose										X	
Green Deer Tongue (48)	Loose							X	X			Open pollinated
Green Ice (45)	Loose							X				For early plantings. Bolts rapidly
Green Star (52)	Loose			X				X	X		X	
Green Vision (54)	Loose										X	
Heatwave (50-60)	Loose							X	X			
Lasting Green MI (65)	Loose							X			X	Open pollinated
Lettony (29-51)	Loose			X								Baby or mature
Loma (46)	Loose								X		X	Open pollinated
Nevada (28-48)	Loose	X		X		X		X			X	Open pollinated, baby or mature head.

Table 6.1 Disease Resistance in Lettuce Varieties.

Variety Name (days to harvest)	**Type**	**Bottom Rot**	**Corky Root Rot**	**Downy Mildew**	**Bacterial Spot**	**Lettuce Mosaic Virus**	**Drop**		**Bolting**	**Heat**	**Brown Rib**	**Tip Burn**	**Comments**
North Star	Loose		X									X	
Prizeleaf (48)	Loose								X	X			
Reine Des Glaces (57)	Batavia								X				Open pollinated
Royal Oak Leaf (47) [2]	Oakleaf								X	X			
Salad Bowl (49)	Loose								X	X			
Simpson Elite (41-53) [2]	Loose								X				Open pollinated
Slobolt (50) [1, 2]	Loose								X	X		X	
Seacrest	Oakleaf			X									
Star Fighter (58)	Loose		X						X			X	
Sulu (28)	Oakleaf			X									Baby greens
Tango (28-45)	Loose								X				Baby or mature heads
Tehama (53)	Loose		X						X			X	
Tiara (46) [1]	Loose												
Tropicana (52) [2]	Loose		X						X	X		X	
Two Star (51) [2]	Loose								X				Open pollinated
Waldmann's Dark Green (60) [1]	Loose								X	X		X	
Blade (30)	Oakleaf			X		X							Baby greens
Bronze Arrowhead [2]	Oakleaf												
Brunia [2]	Oakleaf												
Cherokee (48) [2]	Loose	X		X					X	X			
Cocarde (49) [2]	Oakleaf								X				
Continuity (56)	Loose									X			
Antago (30-53)	Lollo rossa			X									
Fides	Lollo rossa			X									
Dark Lolla Rossa (53)	Lollo rossa			X									
De Morges Braun (64)	Loose								X				Open pollinated
Ferrari (44)	Oakleaf			X									
Firecracker (28)	Loose		X	X									For baby greens
Flashy [2]													
Forte red	Oakleaf			X									
Galactic (58)	Loose			X			X						
Garrison (28)	Oakleaf			X									For baby greens
Jamai (45)	Oakleaf			X									
Magenta red	Loose	X		X		X			X			X	
Malawi (28/51)	Oakleaf								X				
Mascara (65)	Loose								X				Open pollinate
Mercury (55)	Loose			X									
Mottistone (55)	Loose			X									
Nestorix (21-28)	Loose			X									For baby greens
New Red Fire MI (48) [1]	Loose	X		X					X	X		X	Open pollinated

Table 6.1 Disease Resistance in Lettuce Varieties.

Variety Name (days to harvest)	**Type**	**Bottom Rot**	**Corky Root Rot**	**Downy Mildew**	**Bacterial Spot**	**Lettuce Mosaic Virus**	**Drop**		**Bolting**	**Heat**	**Brown Rib**	**Tip Burn**	**Comments**
Oscarde (28-55)	Oakleaf			X									
Prizehead (45) [2]	Loose				X								
Ravessa	Batavia			X		X							
Red Oakleaf (50)	Oakleaf			X			X			X		X	
Red Sails (45) [1, 2]	Loose								X	X		X	Open pollinated
Red Salad Bowl (51) [2]	Oakleaf								X				
Red Tide (28/48)	Loose	X										X	
Red Velvet (55)	Loose												Open pollinated
Revolution (48)	Lollo rossa			X					X				
Rustica (28/60)	Batavia			X	X								
Sierra (50) [1]	Batavia												
Sunfire (28)	Oakleaf			X									For baby greens
Teide (48)	Batavia			X									
Vulcan (52) [2]	Loose									X		X	
High Mowing Salad Blend				X									Open pollinated
ROMAINE/COS													
Brune d'Hiver [2]													
Claremont (28-46)	Cos			X									Baby or mature
Coastal Star (65)	"		X							X			
Dark Green Cos (70) [1]	"												
Defender (28)	"			X									For baby greens
Freckles Forellenschluss (55)	"								X	X			
Green Forest (70)	"								X			X	
Green Towers (70) [1]	"		X										
Ideal Cos (75) [1]	"								X			X	
Jericho (57) [2]	"									X		X	hybrid
King Henry	"									X			
Little Caesar (70)	"											X	
Noga	"								X				
Paramount (67)	"		X										
Parris Island (76) [1]	"					X						X	
PIC 714 (28-57)	"		X									X	
Pinecrest	"			X		X							
Plato II (53)	"					X						X	
Raptor MI (75)	"		X										
Rome 37	"					X							
Rouge d' Hiver (60) [2]	"						X					X	
Rubicon	"		X			X			X	X		X	
Tall Guzmaine (65)	"		X			X				X			
Tigress (65)	"								X	X		X	

Table 6.1 Disease Resistance in Lettuce Varieties.

Variety Name (days to harvest)	**Type**	**Bottom Rot**	**Corky Root Rot**	**Downy Mildew**	**Bacterial Spot**	**Lettuce Mosaic Virus**	**Drop**		**Bolting**	**Heat**	**Brown Rib**	**Tip Burn**	**Comments**
Triton (75)	"									X			
Valmaine (70)	"									X			Open pollinated
Vivian (28/70) [2]	"								X				
COS RED													
Annapolis (28)	Red cos			X									
Breen (45)	"			X									
Eruption (28/50)	"			X		X							
Red Rosie (28/56)	"			X									
Red Zin	"			X	X								For baby greens
Rubane (28/56)	"			X									
Spock (28)	"			X									For baby greens

1- Recommended for New York growers in the Cornell Crop and Pest Management Guidelines, 2- Recommended from organic grower experience, X= tolerant or resistant to the disease or disorder.

7. PLANTING

On average, a lettuce crop reaches maturity in 60 days. On organic farms in New York, lettuce types with a long growing season should be transplanted, not direct seeded. The small lettuce seed establishes more slowly than many weeds. Transplanting the crop makes it more competitive relative to weeds and allows earlier cultivation. For lettuce crops with a shorter cropping interval, such as baby greens, direct seeding into a well prepared seedbed is preferable. Planting information for baby greens is not addressed in this guide.

Spacing both between and within rows should allow adequate air movement to minimize grey mold, bottom rot, and drop. Rows generally are spaced about 15 inches apart and in-row spacing is determined by variety and desired size of the marketed lettuce (see Table 7.0.1). Uniform spacing is important for achieving uniform maturity. Growing on 4' wide and 4" high raised beds enhances air movement and soil drying for improved disease control.

Table 7.0.1 Recommended Spacing

Type	Between Row (inches)	In-row (inches)
Crisphead	12-24	12-18
Other lettuce	10-18	10-16

Lettuce is a cool-season crop, and high temperatures, particularly at night, are detrimental, leading to disorders such as premature bolting, tipburn, and brown rib. Crisphead (iceberg) lettuce is especially sensitive to heat, although some new varieties are more tolerant.

7.1 Direct Seeding

Lettuce will germinate at soil temperatures as low as 32^{0}F, but the optimum and maximum soil temperature is 75^{0}F. Above 80^{0}F, seed will remain dormant until temperatures cool. Because lettuce withstands cold temperatures, the season can be extended through use of high tunnels or unheated greenhouses. Early spring plantings, and fall plantings held through the winter, target the lucrative early markets.

Once-over harvesting is done on most large commercial acreage, so every effort should be made to promote uniform maturity. Purchase the best quality seed available to help ensure uniformity of the crop. Using precision seeding and coated seed can enhance uniformity. Irrigation immediately following seeding promotes consistent emergence. Where irrigation is not possible, deep plowing followed immediately by fitting and seeding is helpful. Washington State University has information on organic seed treatments (reference 52).

7.2 Transplant Production

Transplants can be started in the greenhouse in February or March, and set out in April. Germination rates are generally better in seed planted the greenhouse than seed planted directly into the field. Floating row covers over the bed, used in combination with early transplanting, can produce lettuce for the early market. A good transplant is healthy, stocky, and relatively young. Planting transplants that are at the same stage of growth will help reduce variability at harvest time. Producing such plants requires good light, proper temperature, adequate moisture and a uniform, fertile planting mix. Maintaining optimum soil temperature and moisture will also help to prevent damping-off losses in seedlings. Harden transplants near the end of their growing period by reducing water and moving them outside to a sheltered area. See Section 7.5: *Transplanting*.

Using cell or plug flats will improve transplant uniformity and reduce plant shock at field setting. Plug flats are sold based upon the number of cells per flat (24 to 800 cell plug trays are available). Generally, the more cells per flat, the smaller the volume per cell. Selection of cell number depends on several factors including desired final plant size, fertility options and the estimated time between seeding and transplanting. Plants grown in smaller cells will require more careful monitoring of nutrients and water, but will be ready to transplant sooner. Larger cells provide more soil media, and thus more moisture and nutrients to developing seedlings, but make less efficient use of greenhouse bench space. If using smaller cells, time planting to avoid plants from becoming root bound. Lettuce is commonly grown in flats with 96-200 cells. Seeds are placed singly in individual cells, either by hand or via seeders.

Table 7.2.1 Optimal Temperatures for Growing Transplants

Optimal soil germination temperature	75^0F
Minimum soil germination temperature	32^0F
Optimal day temperature for transplant growth	60-65^0F
Optimal night temperature for transplant growth	50^0F
Weeks from seeding to planting	3-5

7.3 Greenhouse Sanitation and Disease Management

The greenhouse environment is favorable for plant pathogens, and these pathogens are difficult to control. Plants can become infected as seedlings without showing symptoms until they are maturing in the field. No single strategy will prevent greenhouse diseases, however by utilizing multiple management strategies, damage and losses can be minimized.

Preseason Sanitation: Clean and disinfect all greenhouse tables, benches, floors, hoses, flats, containers or anything that comes in contact with plants. It is important to thoroughly clean, **even if there was had no disease last year**. Persistent pathogens could still be present and spread to healthy transplants under optimal environmental conditions. Clean all seedling flats prior to reuse to remove any clinging soil or plant material that may be contaminated with fungi capable of causing damping-off in seedlings. At a minimum, use soap and water with a stiff brush to wash flats and then dry thoroughly in a hot greenhouse prior to storage. Alternatively, flats could be steamed or sanitized prior to use. Chlorine solutions are probably the most effective sanitizers, but the NOP limits the chlorine concentration in discharge water. If you plan to use chlorine, **check with your certifier** to determine its proper use. Thoroughly rinse flats after using sanitizers. Table 7.3.1 lists sanitizers**.** Use new flats to help avoid carry-over of pathogens if disease was severe the previous season.

IPM Strategies in the Greenhouse: Keep the greenhouse weed-free. Some pathogens survive on weed hosts and then move to transplants in the greenhouse. Scout greenhouses weekly for any sign of disease and remove diseased plants immediately. If a diseased plant is identified in a flat, remove the whole flat. Control insects that may spread viruses. Keep foliage as dry as possible to prevent infection. Water in the morning since foliage is likely to dry quickly during the day. Do not brush against or trim when plants are wet to reduce the spread of pathogens.

Table 7.3.1 Disinfectants

Compound **Trade Name** ***Active Ingredient***	**Rate**
CDG Solution 3000 *(chlorine dioxide)*	*For surfaces, equipment and structures:* use 1:12 dilution. *For pots, flats, trays and tools:* use 1:6 dilution.
***GreenClean PRO** (*sodium carbonate peroxyhydrate*)	0.5-2 lbs granular/1000 ft^2
* Restricted-use pesticide in New York State; may be purchased and used only by certified applicators	

Use power sprayer to wash all surfaces and remove plant debris and other organic material before treating. Use to disinfect pots, flats and trays, surfaces, equipment and structures.

7.4 Transplant Growing Mix

A good transplant mix is well drained, has good aeration, supplies a reserve of nutrients, and provides adequate support to developing seedlings. Most organic transplant mixes are based upon a combination of peat moss, vermiculite or perlite and a proportion of stable, cured compost. Soil may be included in an organic mix, but could harbor damping-off pathogens. Organic transplant mixes must not contain any materials prohibited by the NOP, including synthetic fertilizers and most wetting agents. Commercial organic potting media is available. See the OMRI Products list for approved media, wetting agents, and soil amendments (reference 13).

7.5 Transplanting

Prior to field setting, reduce temperature, water, and nutrients for 3-5 days to harden transplants. Gradually expose them to direct sunlight in a protected location, while watching to make sure plants are not stressed. This 'hardening' process helps greenhouse-grown transplants develop a thicker leaf cuticle that resists water stress. Hardening also helps plants accumulate the food reserves needed to expand the root system after field setting. Over mature or stressed transplants usually resume growth slowly and rarely achieve full yields.

To transplant, set plants deep enough to completely cover the media of the plug and firm the soil around the plants to minimize water loss from the plug. Apply water using the transplanter or irrigate immediately after transplanting, especially if the soil is somewhat dry. High temperatures or strong drying winds at the time of transplanting contribute to delayed recovery and increased plant mortality. If possible, avoid planting under such conditions or be prepared to irrigate immediately.

7.6 Planting Dates

Since lettuce is a short-season crop, it can be grown from early spring into late fall, especially when expanding the season through use of high tunnels, floating row covers, or other season extension systems. Cold tolerant lettuce varieties can be planted as soon as the soil is workable in the spring. Lettuce varieties vary in their tolerance to heat and cold. See Table 6.1 or review seed company information to match varieties to the climate conditions.

8. Crop and 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	32
Agri Analysis, Inc.		x	29
A&L Eastern Ag Laboratories, Inc.	x	x	30
Cornell Soil Nutrient Analysis Lab	x		34c
Penn State Ag Analytical Services Lab.	x	x	31
University of Massachusetts	x	x	33
University of Maine	x	x	34

8.1 Fertility

Recommendations from the Cornell Crop and Pest Management Guidelines (reference 1) indicate that a lettuce crop requires 80-100 lbs. of available nitrogen (N), 120 lbs. of phosphorus (P), and 150 lbs. of potassium (K) per acre to support a good yield. These levels are based on the total nutrient needs of the whole plant and assume the use of synthetic fertilizers. Research and grower experience suggests that somewhat lower levels may be adequate in organic systems. See Table 8.2.2 for the recommended rates of N, P, and K based on soil test results. Nitrogen is not included because levels of available N change in response to soil temperature, moisture, N mineralization potential, and leaching. As much 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: Agricultural research indicates that an average lettuce crop requires 80-100 lbs. nitrogen (N), 120 lbs. phosphorus (P), and 150 lbs. 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 Lettuce Based on Soil Tests

	Nitrogen Level	Soil Phosphorus Level			Soil Potassium Level		
Level shown in soil test	Not provided	low	med	high	low	med	high
	N lbs/A	**Pounds/A P_2O_5**			**Pounds/A K_2O**		
Total nutrient recommendation	80-100	120	80	40	150	100	50

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

Line 3b. Manure: Because lettuce is eaten fresh, the use of manure as a nutrient supplement is generally not recommended unless it has been composted with an organically certified process. The NOP rules allow manure applications 120 days or more before harvest, but your farm certifier may have a more restrictive policy.

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

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

Line 4. Total Credits: Add together the various nutrient values from soil organic matter, compost, and cover crops to estimate the total 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 (80-100 lbs/acre), a side-dress application of organic N may be needed. There are several sources of N for organic side-dressing (see Table 8.2.4) as well as pelleted composts. Early in the organic transition, a grower may consider increasing the N budget supply by 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. Because lettuce is eaten fresh, **manure applications may not be allowed by your certifier or marketer. Check with both these sources prior to making manure applications.**

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

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

1-N1 is an estimate of the total N available for plant uptake when compost 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). a injected, b incorporated. Table adapted from Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops by Carl Rosen and Peter Bierman (reference 27) and Penn State Agronomy Guide 2015-16 (reference 28)

Tables 8.2.4-8.2.6 lists some commonly available fertilizers, 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) [a] also contains 2% P and 3% K_2O	500	1000	1500	2000	2500
Fish meal 9% N, also contains 6% P_2O_5	220	440	670	890	1100
Alfalfa meal 2.5% N also contains 2% P and 2% K_2O	800	1600	2400	3200	4000
Feather meal, 15% N (x 1.5) [a]	200	400	600	800	1000
Chilean nitrate 16% N cannot exceed 20% of crop's need.	125	250	375	500	625

a Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil testing lab (reference 34).

Table 8.2.5 Available Phosphorous in Organic Fertilizers.

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

a Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil testing lab (reference 34).

Table 8.2.6 Available Potassium in Organic Fertilizers.

	Pounds of Fertilizer/Acre to Provide X Pounds of K_2O per Acre:				
Sources	**20**	**40**	**60**	**80**	**100**
Sul-Po-Mag 22% K_2O also contains 11% Mg	90	180	270	360	450
Wood ash (dry, fine, grey) 5% K_2O, 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) [a]	8000	16000	24000	32000	40000
Potassium sulfate 50% K_2O	40	80	120	160	200

a Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Adapted by Vern Grubinger from the University of Maine soil testing lab (reference 34).

An example of how to determine nutrient needs for lettuce.

You will be growing an acre of leaf lettuce. The Cornell Crop and Pest Management Guidelines suggests a total need of 80-100 lb. N, 120 lb. P, and 150 lb. K per acre to grow a high yielding crop. Soil tests show a pH of 6.0, with high P. Looking at table 8.2.2, this means 40 lbs P_20_5/A is recommended. Potassium levels are medium according to the soil test, therefore 100 lbs K_20/A are recommended. The field has 2% organic matter. Last fall 3 tons/acre of composted dairy manure were spread and immediately incorporated prior to planting a cover crop of oats. Nutrient credits for soil organic matter, composted dairy manure, and cover crops appear in Table 8.2.7.

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

	Nitrogen (N) lbs/acre	Phosphate (P_2O_5) lbs/acre	Potash (K_2O) lbs/acre
1. Total crop nutrient needs:	80-100	120	150
2. Recommendations based on soil test	# not provided	40	100
3. Credits			
a. Soil organic matter 2%	40	---	---
b. Manure			
c. Compost –dairy manure 3T/A	9	30	69
d. Cover crop – oat	-	-	-
4. Total credits:	49	30	69
5. Additional needed (2-4) =	40	10	31

Estimate nitrogen first. Each percent organic matter will release about 20 lbs of N, so the 2% organic matter will supply 40 lbs/A (line 3a). Line 3c is calculated using Table 8.2.3 which indicates about 9 lbs N will be released in the first season from the 3 tons/A of composted dairy manure (N1). The total estimated N released and available for plant uptake is 49 lbs per acre (line 4). Line 5 suggests that 40 lbs/A of N is still needed, which can be added by side-dressing with 1,000 lbs/A of soy meal.

Phosphorus and potassium will also need to be supplemented. Looking at P, the compost supplies 30 of the 40 lbs/A recommended based on the soil test. Apply 65 lbs/A of bonemeal to meet the 10 lb/A phosphorus deficit (Table 8.2.5). About 70 lbs/A of the potassium needs are supplied by the composted dairy manure out of the 100 lbs/A recommended. The remaining 30 lbs K_2O/A can be added by applying 135 lbs./A of Sul-Po-Mag, broadcast and then incorporated (Table 8.2.6).

Additional Resources
Using Organic Nutrient Sources (reference 34a)
Determining Nutrient Applications for Organic Vegetables (reference 34b)

9. HARVESTING

Care in harvesting and handling is important for lettuce crops since they are easily damaged.

Table 9.0 Average Days to Harvest for Lettuce Types

Lettuce Type	Average days to harvest after seeding
Crisphead	70-80
Butter and Bibb	50-60
Romaine	60-70
Leaf	50-60

Reference 12a

9.1 Harvest Methods

Crisphead: Harvest when the full-sized head can be slightly compressed with moderate hand pressure. Loose heads are immature, and overly hard heads are past maturity. Over mature heads tend to lack flavor and have increased postharvest problems. Leave 3 to 4 wrapper leaves to protect the heads. Properly harvested and trimmed heads should have a bright green color and be crisp.

Romaine: Harvest romaine when mature heads have about 35 leaves per head after trimming, and are not too loose or tight. Romaine loses its flavor when over mature, and has more postharvest problems. The marketable head should have brightly colored outer leaves. Romaine "hearts" are the tender inner leaves trimmed from plants that are slightly immature. Leaves of all harvested lettuce should be crisp and free from insect, decay, or mechanical damage. Varieties differ in flavor at maturity, so consider the desires of the target market when choosing varieties to plant (reference 12b).

Freeze damage to leaves can cause subsequent decay in many lettuce types. Damage can occur in storage if temperatures drop below 31.7°F. Damaged tissue looks water-soaked and will deteriorate after thawing (reference 12b).

See US Department of Agriculture standards for
Lettuce grades (reference 12c).
Field grown leaf lettuce (reference 12d).

9.2 Storage

Non-crisphead varieties are more susceptible to damage during harvest and transit and therefore have a shorter shelf life than crisphead varieties. Optimum storage conditions are

32°F with at least 95 percent relative humidity. Air flow through and around boxes is essential. Vacuum cooling is effective at quickly reducing the field temperature of the produce, but forced-air cooling can also be successful (reference 1 and 12b). Rapid cooling will improve market quality and shelf life. Use top ice during packaging to supply moisture and remove heat. Always use ice made from potable water.

Lettuce Type	Average Shelf-life at 32°F	Average Shelf-life at 41°F
Crisphead	21-28	14
Romaine	21 days	14
Leaf and butterhead	7-14	na

References 12a and 12b

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 10) or the Produce Safety Alliance (reference 10a). 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 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 pests 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 biocontrol organisms as their active ingredient (e.g. Contans). The active ingredients of some biological pesticides (e.g. Serenade) are actually a metabolic by product 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, while applying too little can fail to control pests or lead to pesticide resistance.

Resources

Calibrating Backpack Sprayers (reference 45)
Cornell Crop and Pest Management Guidelines: Pesticide Information and Safety (reference 46)
Pesticide Environmental Stewardship: Calibration (reference 47)
Knapsack Sprayers – General Guidelines for Use (reference 48)
Herbicide Application Using a Knapsack Sprayer (reference 49) This publication is also relevant for non-herbicide applications.
Pesticide Environmental Stewardship, Coop Extension (reference 49a)
Pesticide Environmental Stewardship, CIPM (reference 49b)
Vegetable Spraying (reference 49c)

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) requirements for use in New York State. See Cornell's Product, Ingredient, and Manufacturer System website (reference 11) for pesticides currently registered for use in NYS. Additional products may be available for use in other states.

To maintain organic certification, products applied must also comply with the National Organic Program (NOP) regulations as set forth in 7 CFR Part 205, sections 600-606 (reference 18). The Organic Materials Review Institute (OMRI) (reference 13) is one organization that reviews products for compliance with the NOP regulations and publishes lists of compliant products, but other entities also make product assessments. Organic growers are not required to use only OMRI listed materials, but the list is a good starting point when searching for allowed pesticides.

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

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

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

Worker Protection Standard training. If the farm has employees who will be working in fields treated with a pesticide, they must be trained as workers or handlers as required by the federal Worker Protection

Standard (WPS). Having a pesticide applicator certification is one of the qualifications needed to be a WPS trainer. Certified pesticide applicators meet the WPS training requirements. For more information on the Worker Protection Standard see: How To Comply with the Worker Protection Standard (reference 21b). See Revisions To the Worker Protection Standard for a summary of new worker protection standards that will take effect January 2017. Find more information on pesticide applicator certification from the list of State Pesticide Regulatory Agencies (reference 21c) or, in New York State, see the Cornell Pesticide Management Education Program website at http://psep.cce.cornell.edu (reference 21d).

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 2) 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. Check the OMRI Products List for adjuvants, under *Crop Management Tools and Production Aids* (reference 13). 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 important diseases whenever possible (see Section 6: *Varieties*). Plant only clean, vigorous and pathogen-free seed or transplants and maintain the best growing conditions possible.

Rotation is an important management practice for pathogens that overwinter in soil or 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 *Pythium*, *Rhizoctonia*, and *Sclerotinia*. Rotation with a grain crop, preferably a crop or crops that will be in place for one or more seasons, deprives many disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. The same practices are effective for preventing the buildup of root damaging nematodes in the soil, but keep in mind that certain grain crops are also hosts for some nematode species. See more 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 parallel to the prevailing wind, using a wider row spacing, or controlling weeds can slow disease development. Fields surrounded by trees or brush that tend to hold moisture after rain, fog or dew should be avoided.

Scouting fields weekly is key to early detection and evaluation of control measures. The earlier a disease is detected, the more likely it can be suppressed with organic fungicides. 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 farm 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 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. 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 regulations regarding pesticide applications. See Section 10: *Using Organic Pesticides* for details. **ALWAYS check with your organic farm certifier when planning pesticide applications**.

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 11.0.1 Pesticides for Disease Management in Organic Lettuce

CLASS OF COMPOUND Product name *active ingredient*	**Anthracnose**	**Bottom Rot**	**Damping-off**	**Downy Mildew**	**Drop**	**Gray Mold**	**Viruses**
MICROBIAL							
Actinovate AG *Streptomyces lydicus*	X	X	X	X	X	X	
Actinovate STP *Streptomyces lydicus*		X	X				
BIO-TAM *Trichoderma asperellum, Trichoderma gamsii*		X	X				

CLASS OF COMPOUND Product name *active ingredient*	Anthracnose	Bottom Rot	Damping-off	Downy Mildew	Drop	Gray Mold	Viruses
BIO-TAM 2.0 *Trichoderma asperellum, Trichoderma gamsii*		X	X		X		
Contans WG *Coniothyrium minitans*					X		
Double Nickel 55 Biofungicide *Bacillus amyloliquefaciens str. D747*		X	X	X	X		
Double Nickel LC Biofungicide *Bacillus amyloliquefaciens str. D747*		X	X	X	X		
Mycostop Biofungicide *Streptomyces griseoviridis*			X			X	
Mycostop Mix *Streptomyces griseoviridis*			X				
Optiva *Bacillus subtilis str. QST 713*					X		
Prestop Biofungicide *Gliocladium catenulatum str. J1446*		X	X			X	
Regalia Biofungicide *Reynoutria sachalinensis*				X	X		
RootShield Granules *Trichoderma harzianum*		X	X				
RootShield PLUS+ Granules *Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*		X	X				
Rootshield WP *Trichoderma harzianum Rifai str. KRL-AG2*		X	X				
RootShield PLUS+ WP *Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*		X	X				
Serenade ASO *Bacillus subtilis* str QST 713				X	X		
Serenade MAX *Bacillus subtilis* str QST 713				X	X		
Serenade SOIL *Bacillus subtilis* str QST 713		X			X		
Serenade Opti *Bacillus subtilis* str QST 713					X		
					X		
SoilGard *Gliocladium virens*		X	X				
Taegro Biofungicide *Bacillus subtilis*		X					
Taegro ECO *Bacillus subtilis*		X			X		
BOTANICAL							
Trilogy *neem oil*	X			X		X	
COPPER							
Badge X2 *copper oxychloride, copper hydroxide*	X			X			
Basic Copper 53 *basic copper sulfate*	-			X			
ChampION++ *copper hydroxide*				X			
Cueva Fungicide Concentrate *copper octanoate*		X		X			
Nordox 75 WG *copper hydroxide*				X			
Nu-Cop 50 WP *copper hydroxide*				X			
Nu-Cop 50DF *copper hydroxide*				X			
Nu-Cop HB *cupric hydroxide*				X			
OIL							
PureSpray Green *mineral oil*							X
Organic JMS Stylet Oil *paraffinic oil*							X
Organocide 3-in-1 *sesame oil*				X			
MilStop *potassium bicarbonate*	X			X		X	
OTHER							
Agricure *potassium bicarbonate*	X			X		X	
Green Cure *potassium bicarbonate*	X			X		X	
OxiDate 2.0 *hydrogen dioxide, peroxyacetic acid*				X		X	
PERpose Plus *hydrogen peroxide/dioxide*	X	X	X	X	X	X	
TerraClean 5.0 *hydrogen dioxide, peroxyacetic acid*		X	X			X	

X –Product for use on lettuce in New York state and OMRI listed.

Active ingredient meets EPA criteria for acute toxicity to bees

11.1 Anthracnose, *Microdochium panattonianum*

Time for concern: Cool wet weather favors this fungus.

Key characteristics: Water-soaked, circular spots first appear on the undersides of leaves that when dry, give a shot hole appearance. These spots are often angular in shape, bounded by the larger leaf veins. Lesions on the midrib begin as water-soaked spots, but become markedly sunken. Young plants can be killed and older plants disfigured. The fungus survives in the soil and on crop debris and is spread locally by wind and rain (Reference 50).

Relative Risk: sporadic and normally of minor importance

Management Option	Recommendation for Anthracnose
Scouting/thresholds	**Scouting:** Look for spots on the outermost foliage and along the midrib on the lower leaf surface. **Thresholds** for organic production have not been established.
Crop rotation	Maintain a minimum of 1 year without lettuce or other susceptible crops.
Resistant varieties	Anthracnose affects most lettuce varieties.
Planting	Plant rows in the direction of the prevailing winds to promote quick drying of plants.
Seed selection	This pathogen is seed-borne. Plant disease-free seed. See reference 52 for treatment options for seed lots with suspected infestations.
Weed control	Remove alternate host weeds in the genus *Lactuca* such as prickly lettuce and wild lettuce, from areas in and around lettuce fields. Do not cultivate when plants are wet to reduce the spread of disease.
Cultural controls	Wet weather and irrigation provide conditions conducive to spore production and dispersal. Ground level irrigation is preferred over sprinklers. Irrigate early in the day when sun or wind are likely to dry leaves quickly. Avoid working in fields when the foliage is wet.
Harvest	Packing infected plants with healthy ones can spread disease.
Postharvest	The fungus survives in the soil and on crop debris. Fields should be deep plowed after harvest to bury infested plant debris.

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 11.1 Pesticides for Management of Anthracnose

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.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Badge X2 (copper hydroxide, copper oxychloride)	0.75-1.5 lb/acre	0	48	?	
Milstop (Potassium bicarbonate)	2-5 lb/acre	0	1	?	

Table 11.1 Pesticides for Management of Anthracnose					
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal (initial/curative)	-	until dry	?	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.
PERpose Plus (hydrogen peroxide)	0.25-0.33 fl.oz./ gal (weekly/preventative)	-	until dry	?	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.
Trilogy (neem oil)	0.5-1% solution	up to day	4	?	Apply no more than 2 gallons of Trilogy per acre per application. Bee Hazard. This product is toxic to bees exposed to direct contact

PHI = pre-harvest interval, REI = restricted entry interval - = pre-harvest interval isn't specified on label Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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

11.2 Botrytis Gray Mold, *Botrytis cinerea*

Time for concern: The fungus grows within a wide range of temperatures, but is favored by cool (65^{o} to 75^{o}F), moist conditions, either in greenhouses or field locations. Plants are susceptible at all stages.

Key characteristics: Gray mold is especially common in the cool moist conditions of greenhouses or high tunnels. Symptoms of affected seedlings are similar to those of damping-off. The pathogen initially develops on damaged or dead tissue when wet, or tissue that is touching soil. It can then spread to adjacent healthy tissue. Initial symptoms are brownish to black water-soaked lesions that become a mushy rot. The pathogen can spread from lesions on the margins of outer leaves to the stem. Profuse gray-brown conidia (spores) develop and may be followed by black resting bodies (sclerotia). Affected plant parts rapidly turn soft and rot. The fungus can also grow up the stem and rot the inside of a head causing the plant to collapse before any outward symptoms are visible. Infection can spread through heads after harvest affecting marketability. The gray mold fungus is widespread, surviving on the dead or dying tissue of many plants. Consequently management is largely dependent on selecting sites and planting dates which provide warmer and drier conditions. View photos (reference 2, page 93, reference 55 and reference 1).

Relative Risk: Gray mold is one of the three most important diseases of head lettuce, particularly in greenhouse or high tunnel lettuce. Because the fungus is ubiquitous, the risk of gray mold can be widespread dependent on favorable weather conditions.

Management Option	Recommendation for Gray Mold
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Site selection	Select a well-drained field with good air flow that will help dry leaves and soil quickly.
Crop rotation	Rotation alone will not manage this ubiquitous fungus, although it may help reduce the pathogen population.
Resistant varieties	Resistant varieties are not known.
Seed	This fungus is not seed-borne.
Planting	Orient rows parallel to the prevailing winds and use wide row spacing to encourage quick drying of leaves and soil. Plant in fields where crop debris is well decomposed at planting time. Wounded transplants are more prone to gray mold development: transplant before seedlings are large and overly mature. Since Romaine is particularly susceptible, direct seeding is recommended over transplanting.
Weed control	Avoid wounding plants during early cultivation to prevent infection.

Management Option	Recommendation for Gray Mold
Cultural controls	Maintain low moisture and humidity levels in greenhouse and high tunnel production. Strict hygiene is essential in plant bed and greenhouse settings
Harvest	Trim off affected leaves. Keep harvested plants refrigerated between 32oF and 36oF.
Postharvest	Plow under debris after harvest.
Note(s)	Avoid use of overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when sun or wind are more likely to quickly dry leaves. Damage from frost, heat or other disease can predispose lettuce to infection by *Botrytis cinerea* as can physiological disorders such as tipburn.

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 Botrytis Gray Mold

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces ydicus* WYEC 108)	3-12 oz/acre	0	1 or until dry	?	The label recommends use of a spreader sticker.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Milstop (potassium bicarbonate)	2-5 lb/acre	0	1	?	
MycoStop (*Streptomyces grieoviridis* str. K61)	0.1% solution by weight	-	4	?	Only provides suppression of botrytis. Apply to runoff. Labeled only for greenhouse use.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water	0	until dry	?	Apply consecutive applications until control is achieved and then follow directions for preventative treatment. Bee Hazard. This product is toxic to bees exposed to direct contact
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl oz/100 gal water	0	until dry	?	Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce to preventative rate after the completion of the third treatment and maintain 5-day interval spray cycle. Bee Hazard. This product is toxic to bees exposed to direct contact
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal initial/curative 0.25-0.33 fl.oz./ gal 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.
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil treatment	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.

Table 11.2 Pesticides for Management of Botrytis Gray Mold					
Trilogy (neem oil)	0.5-1% solution	up to day	4	?	Apply no more than 2 gallons of Trilogy per acre per application. Bee Hazard. This product is toxic to bees exposed to direct contact

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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 Bottom Rot and Wirestem, *Rhizoctonia solani*

Time for concern: Warm, wet conditions favor this fungus. It is most prevalent soon after planting and as heads begin to form.

Key characteristics: Bottom rot and wirestem are two phases of the same disease.

Bottom rot is generally seen in late plantings near the time of harvest, on leaves that are in direct contact with the soil. Rust-colored lesions appear on the leaf midrib and may expand to the whole leaf. Lesions turn brown and desiccate when conditions are dry, but will resume infection when moisture increases. Bottom rot symptoms are similar to other fungal infections. Lettuce drop has white mycelium, but bottom rot does not, and gray mold has gray spore masses which are absent in bottom rot. The fungus overwinters in the soil or on decaying plants as either mycelia or sclerotia. See photo (reference 56) and reference 50.

Wirestem is a late damping-off disease. See Section 11.4.

Relative Risk: Bottom rot is one of the most important fungal diseases of lettuce.

Management Option	Recommendation for Bottom Rot and Wirestem
Scouting/thresholds	Scout plantings weekly. Thresholds have not been established for organic production.
Site selection	Select a well-drained field with good air flow to encourage quick drying of leaves and soil. In fields with a history of bottom rot, use 4” raised beds to create a drier field situation. Do not plant in fields with a significant quantity of incompletely decomposed crop residues.
Crop rotation	Rotate away from lettuce and endive for a minimum of 3 years. Cover crops in the grass family will help to reduce the pathogen population in the soil. Highly susceptible alternate hosts include beans, lettuce, cabbage, and potato, although many others are hosts too including broccoli, carrot, cress, cucumber, eggplant, endive, escarole, kale, pepper, potato, radish, tomato, and turnip.
Seed selection	This disease is not seed-borne.
Resistant varieties	A few resistant varieties are available (see Section 6: *Varieties*). Upright varieties are less susceptible because their leaves do not touch the soil.
Planting	Plant in widely spaced rows, parallel with the prevailing winds to encourage quick leaf drying.
Weed control	Control weeds to improve air flow and shorten leaf wetness periods throughout the field. Many common weeds serve as alternate hosts: barnyardgrass, field bindweed, annual bluegrass, wild buckwheat, corn chamomile, chickweed, large crabgrass, green foxtail, goosegrass, field horsetail, kochia, common lambsquarters, prickly lettuce, Venice mallow, black medic, common milkweed, mouseear, wild mustard, eastern black nightshade, common purslane, shepherd’s purse, tumble pigweed, redroot pigweed, prostrate pigweed, common ragweed, Italian ryegrass, perennial sowthistle, and witchgrass (reference 3).
Cultural controls	Planting on raised beds improves air circulation and can reduce disease incidence. Avoid use of overhead irrigation to prevent extended periods of leaf wetness especially near the time of harvest.

Management Option	Recommendation for Bottom Rot and Wirestem
Postharvest	Deep plow to bury plant debris after harvest. Sclerotia do not survive well at deep soil depths, and the pathogen is less likely to come into contact with host plants.

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 Management of Bottom Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (*Streptomyces lydicus* WYEC 108)	3-12 oz/acre soil treatment	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)*	2-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	2.5-5 lb/acre	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal (initial/curative) 0.25-0.33 fl.oz./ gal (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.
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.
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*)	0.25-1.5 lb/ 20 gal water dip	0	4	?	Do not apply when above-ground harvestable food commodities are present.
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.

Table 11.3 Pesticides for Management of Bottom Rot					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
RootShield WP (*Trichoderma harzianum*)	16-32 oz/acre	-	until dry	?	In-furrow or transplant starter solution.
Serenade Soil[1] (*Bacillus subtilis str* QST 713)	2-6 qt/acre soil drench	0	4	?	
Soilgard (*Gliocladium virens*)	1/2-2 lb/100 gal water	-	0	?	At transplant.
Soilgard (*Gliocladium virens*)	2-10 lb/acre	-	0	?	Used as a directed spray or drench at the base of the plant after transplanting.
Taegro (*Bacillus subtilis*)	2.6 oz/100 gal water in-furrow treatment	-	24	?	Soil drench or over furrow at time of planting.
Taegro ECO (*Bacillus subtilis var. amyloliquefaciens* str. FZB2)	2.6-5.2 oz/acre in-furrow treatment	-	24	?	In furrow with seed or at 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/transplanting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl.oz./ 200 gal water soil drench	up to day	0	?	Soil drench with established plants.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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 Damping-off, *Pythium spp., Rhizoctonia solani*

Time for concern: Most common when conditions are excessively moist such as in a site that drains poorly in combination with cool temperatures that slow seed germination and early plant growth.

Key characteristics: These soil borne fungi are present in most soils, but are often kept in balance by other beneficial fungi in well-managed, biologically active soils. They can kill seeds and young seedlings. Damping-off is expressed as seed decay, rot of newly germinated roots, and infections of seedling stems at the soil line after emergence. See the Compendium of Lettuce Diseases (reference 50.)

Relative risk: Although rarely seen, given the right conditions, plantings can be severely reduced especially in early spring in direct seeded fields.

Management Option	Recommendation for Damping-off
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Seed selection	Because fresh seed is generally more vigorous than older seed, plants from fresh seeds may grow faster and exit the highly susceptible seedling state sooner.
Site selection	Avoid compacted, heavy, or poorly drained soils. High levels of decomposing organic matter can increase damping-off and reduce germination rates.
Resistant varieties	Resistant varieties are not known.
Weeds	Several weeds host *Pythium:* wild-proso millet, shattercane, barnyardgrass, quackgrass, and yellow foxtail (reference 3).

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 Management of Damping-off

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 treatment	0	1 or until dry	?	
Actinovate AG (*Streptomyces lydicus* WYEC 108)	2-18 oz/acre seed treatment	0	1 or until dry	?	2-18 oz/4 oz water per acre of seed (seed spray). 2-18 oz/acre of seed (hopper box dry coating).
Actinovate STP (*Streptomyces lydicus*)	4-32 oz/cwt 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*)	2-3 lb/acre band	-	1	?	
BIO-TAM 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	2.5-5 lb/acre	-	4	?	
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
MycoStop (*Streptomyces grieoviridis* str K61)	.176 oz/ 1.5 lbs seed seed treatment	-	4	?	Greenhouse use only. Provides suppression.
MycoStop (*Streptomyces grieoviridis* str K61)	.07 oz/ 100-200 sq ft soil treatment	-	4	?	Greenhouse use only. Provides suppression. Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop Biofungicide into the root zone.
MycoStop Mix (*Streptomyces grieoviridis* str K61)	0.015-0.03 oz/lb seed seed treatment	-	4	?	
MycoStop Mix (*Streptomyces grieoviridis* str K61)	0.0175-0.07 oz/ 100 sq ft soil treatment	-	4	?	
PERpose Plus (hydrogen peroxide)	1 fl oz/ gal initial/curative 0.25-0.33 fl oz/ gal 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.

Table 11.4 Pesticides for Management of Damping-off					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Prestop (*Gliocladium catenulatum*)	1.4-3.5 oz/ 2.5 gal water soil drench	-	0	?	Treat only the growth substrate when above-ground harvestable food commodities are present.
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*)	0.25-1.5 lb/ 20 gal water dip 16-32 oz/acre in-furrow treatment	0	4	?	Do not apply when above-ground harvestable food commodities are present.
RootShield WP (*Trichoderma harzianum*)	16-32 oz/acre	-	until dry	?	In-furrow or transplant starter solution.
Soilgard (*Gliocladium virens*)	0.5-2 lb/100 gal water soil drench	-	0	?	Before transplanting, apply 4 fl oz of finished drench per plant in flats 1 week prior to transplanting. At transplanting, apply 4-8 fl oz of finished drench in each transplant hole.
Soilgard (*Gliocladium virens*)	2-10 lb/acre	-	0	?	Used as a directed spray or drench at the base of the plant after transplanting.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water soil treatment	up to day	0	?	Soil treatment prior to seeding/transplanting.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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 Downy Mildew, *Bremia lactucae*

Time for concern: Ideal conditions for disease development include night temperatures of 43 to 50^{0}F and day temperatures of 55 to 70^{0}F with 100% humidity or long periods of leaf wetness. As temperatures increase, the disease subsides.

Key characteristics: Downy mildew first appears on leaves as light green lesions, turning yellow and chlorotic. Older lesions are tan and papery. White sporangia and spores emerge on the underside of leaves and provide an avenue for other pathogens to enter. Downy mildew overwinters in New York on decomposing residue of infected plants. Spores can be spread by winds. See Cornell photo (reference 57).

Relative Risk: Downy mildew is sporadic but very destructive when present. Plants are susceptible at all stages of growth.

Management Option	Recommendation for Downy Mildew
Scouting/thresholds	Thresholds for organic production have not been established.
Site selection	Select a well- drained field with good air flow that encourages leaves and soil to dry quickly especially for early and late season plantings. Plant in fields where crop debris is well decomposed at planting time.

Management Option	Recommendation for Downy Mildew
Crop rotation	Crop rotation is the first line of defense. Rotate away from lettuce for a minimum of 2 to 3 years.
Seed selection	This fungus is not seed-borne.
Resistant varieties	Breeding resistant varieties is a challenge since the fungus readily produces new races. See resistant varieties in Section 6.
Planting	Orient rows parallel with the prevailing winds and use wide row spacing to promote quick drying of leaves and soil.
Cultural practices	Avoid overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when sun or wind are likely to dry leaves rapidly.
Weed control	Control alternate hosts such as perennial sowthistle, annual sowthistle, and prickly lettuce (reference 3). Control weeds to improve air flow and shorten leaf wetness periods throughout the field.
Postharvest	Plow, rather than disk, to deeply bury diseased crop residue.

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 Management of Downy Mildew

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.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Badge X2 (copper hydroxide, copper oxychloride)	0.75-1.5 lb/acre	0	48	?	
Basic Copper 53 (basic copper sulfate)	1-1.9 lb/acre	up to day	48	?	Copper will leave a visible residue on leaves.
ChampION++ (copper hydroxide)	0.75-1.5 lb/acre	0	48	?	
Cueva Fungicide Concentrate (copper octanoate)	0.5-2 gal/acre	up to day	4	?	Use lower rate for copper-sensitive lettuce varieties.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	2-3 lb/acre	0	4	?	
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre foliar spray	0	4	?	
Milstop (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Nordox 75 WG (cuprous oxide)	0.66-1.25 lb/acre	-	12	?	

Table 11.5 Pesticides for Management of Downy Mildew					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Nu-Cop 50 WP (copper hydroxide)	1-2 lb/acre	1	24	?	Copper will leave a visible residue on leaves.
Nu-Cop 50DF (copper hydroxide)	1-2 lb/acre	1	48	?	Copper will leave a visible residue on leaves.
Nu-Cop HB (copper hydroxide)	1/2-1 lb/acre	-	48	?	Copper will leave a visible residue on leaves.
Organocide (sesame oil)	1-2 gal/100 gal water	0	0	?	25(b) pesticide.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water Curative 32 fl oz/100 gal water Preventative	0	until dry	?	Apply consecutive applications until control is achieved and then follow directions for preventative treatment. Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce to preventative rate after the completion of the third treatment and maintain 5-day interval spray cycle. Bee Hazard. This product is toxic to bees exposed to direct contact
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal initial/curative 0.25-0.33 fl.oz./ gal weekly/preventative	-	until dry	3	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. Hydrogen peroxide effective in 0/1 trial.
Regalia (*Reynoutria sachalinensis*)	0.5-4 qt/acre	0	4	?	
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	
Taegro ECO (*Bacillus subtilis* var. amyloliquefaciens str. FZB2)	2.6-5.2 oz/acre	-	24	?	
Trilogy (🐝 neem oil)	0.5-1% solution	Up to day	4	?	Apply no more than 2 gallons of Trilogy per acre per application. Bee Hazard. This product is toxic to bees exposed to direct contact.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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 Drop, *Sclerotinia sclerotiorum, Sclerotinia minor*

Time for concern: This fungus is favored by warm, wet conditions and is primarily noticed at or near crop maturity, but may occur at any time during the season.

Key characteristics: Also referred to as lettuce drop, white mold, or watery soft rot. The fungus attacks the petioles of outer leaves that contact soil causing the outer leaves to wilt. It quickly progresses inward until the entire plant wilts. Look for soft watery decay, snowy white mycelium, and hard, seed-size, black sclerotia (*Sclerotinia minor* sclerotia are the size of mustard seed; *Sclerotinia sclerotiorum* are the size of pea seed). Sclerotia drop to the ground from decaying plant tissue where they can remain dormant for up to 5 years. Under favorable conditions, the fungus becomes active and spreads throughout soil. Preventing a buildup of the sclerotia in the soil is important, but can be difficult since *Sclerotinia* has many plant hosts. View University of California fact sheet (reference 58) and Cornell photo(reference 59) and reference 50.

Relative risk: Sclerotinia drop is one of the three most serious fungal diseases of lettuce, found wherever inoculum is present and weather is warm and wet. It can cause the entire plant to collapse in days.

Management Option	Recommendation for Drop
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Site selection	Growers who experience only occasional outbreaks during seasons of prolonged wet weather can adequately control lettuce drop with practices that promote quick leaf drying such as controlling weeds, planting in areas of good air movement and adequate drainage. Avoid fields with a history of *Sclerotinia* infections in other crops.
Crop rotation	*Sclerotinia* has a wide host range, making it difficult to manage with crop rotation alone. Under low to moderate disease pressure, a 3-year rotation with non-hosts, particularly grains such as corn, cereal, or forage grass is best, although rotations with onions and potatoes can also be used. In severe situations, a 5-year rotation is necessary. Drop has many hosts including weeds and vegetables such as carrots, cabbage, beans, tomatoes and celery. It is a major disease of chicory and endive. Although broccoli can be an alternate host for *Sclerotinia,* research has shown that planting late-season lettuce after a spring broccoli crop decreases the amount of lettuce drop if the broccoli residue is incorporated prior to planting. A biofumigant mustard cover crop may have a similar effect. See Section 3.5: *Biofumigant Cover Crops.*
Resistant varieties	A few varieties have shown some tolerance to lettuce drop. See section 6: *Varieties*.
Seed selection	This fungus is not seed-borne, but the seed-like fruiting structures (sclerotia) can contaminate seed lots. Do not plant seed if contaminated.
Planting	Orient rows with the prevailing winds and use wide row spacing to encourage quick drying of leaves and soil. Plant in fields where crop debris is well decomposed at planting time.
Weed control	Control weeds to improve air flow and shorten leaf wetness periods throughout the field. Weed hosts of *S. sclerotiorum* include common chickweed, green foxtail, common lambsquarters, prickly lettuce, wild mustard, eastern black nightshade, field pennycress, redroot pigweed, wild radish, common ragweed, shattercane, annual sowthistle, common sunflower, and Canada thistle. *S. minor* is hosted by yellow nutsedge (reference 3).
Cultural controls	Too much nitrogen causes excess quick growing tissue which is more susceptible to lettuce drop. Remove infected plants to prevent spread throughout the field.
Harvest	Trim outer leaves before packing to avoid spreading rot in storage. Refrigerate plants after harvest.
Postharvest	Immediately plow under plant residues after harvest. For extreme cases, flood the field between crops for 23-45 days to reduce inoculum. Flooding causes spores to release when no host is present.

Management Option	Recommendation for Drop
Note(s)	Avoid use of overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when leaves are likely to dry quickly in the sun and wind.

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 Drop

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	3	The label recommends use of a spreader sticker. Streptomyces lydicus products effective in 0/2 trials. Foliar spray and soil treatment.
Bio-Tam 2.0 (*Trichoderma asperellum, Trichoderma gamsii*)	2.5-5 lb/acre	-	4	?	
Contans WG (*Coniothyrium minitans*)	2 lb/acre soil treatment	-	4	2	Contans effective in 9/22 trials. See label for specific use instructions.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.25-3 lb/acre foliar spray	0	4	?	Make second application at thinning or cultivation in sufficient water and multiple nozzles to ensure thorough coverage of lower leaves and surrounding soil surface. Incorporation with light irrigation after application may improve disease control. Repeat at 10-14 day intervals if conditions promoting disease persist.
Double Nickel 55 (*Bacillus amyloliquefaciens* str D747)	0.125-1 lb/acre band	0	4	?	Banded seedline treatment.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-4.5 pts/acre band	0	4	?	Banded seedline treatment.
Double Nickel LC (*Bacillus amyloliquefaciens* str D747)	0.5-6 qt/acre foliar spray	0	4	?	Make second application at thinning or cultivation in sufficient water and multiple nozzles to ensure thorough coverage of lower leaves and surrounding soil surface. Incorporation with light irrigation after application may improve disease control. Repeat at 10-14 day intervals if conditions promoting disease persist.
Optiva (*Bacillus subtilis* str. QST 713)	14-24 oz/acre	0	4	?	Repeat applications on 10-14 day intervals if conditions for disease development persist. Foliar spray and soil treatment.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal initial/curative	-	until dry	?	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.
PERpose Plus (hydrogen peroxide)	0.25-0.33 fl.oz./ gal weekly/preventative	-	until dry	?	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.

Table 11.6 Pesticides for Management of Drop					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Regalia (*Reynoutria sachalinensis*)	0.5-4 qt/acre	0	4	?	
Serenade ASO[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre	0	4	?	Foliar spray and soil treatment.
Serenade MAX[1] (*Bacillus subtilis* str QST 713)	1-3 lb/acre	0	4	?	Foliar spray and soil treatment.
Serenade Opti [1] (*Bacillus subtilis* str QST 713)	14-20 oz/acre	0	4	?	Foliar spray and soil treatment.
Serenade Soil[1] (*Bacillus subtilis* str QST 713)	2-6 qt/acre Soil treatment	0	4	?	
Taegro ECO (*Bacillus subtilis* var. amyloliquefaciens str. FZB2)	2.6-5.2 oz/acre in-furrow treatment	-	24	?	In furrow with seed or at planting.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [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 Aster Yellows *aster yellows phytoplasma*, vectored by the aster leafhopper.

Time for concern: June through September; the occurrence of aster yellows (AY) follows the migration pattern of leafhoppers (Section 14.1).

Key characteristics: The disease is caused by a unicellular phytoplasma which overwinters in the body of the aster leafhopper as well as in perennial and biennial host plants, particularly grains. The disease is transmitted during leafhopper feeding. Leafhoppers must feed on an infected plant for about 8 hours to ingest enough phytoplasma to become infective, and can remain infectious for nearly 100 days. Symptoms include strikingly yellowed, blanched, or chlorotic leaves. Leaves are short and thick in the middle of the head, and the outside leaves become yellow, bitter, and unmarketable. See photo (reference 60), factsheet (reference 61) and reference 50.

Relative risk: Aster yellows causes plants to be severely stunted and yellowed, making them unmarketable. Damage varies from year to year according to the level of aster leafhopper present.

Management Option	Recommendations for Aster Yellows
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Site selection	Do not plant in fields with a previous history of aster yellows. Weeds surrounding these fields often harbor the pathogen.
Crop rotation	The aster yellows phytoplasma has a wide host range, including lettuce, carrot, escarole, endive, and celery. The aster leafhopper tends to overwinter on wheat, rye, barley and some grasses, therefore plant lettuce away from grain fields grown during the previous season. Over 300 species of plants are susceptible, including many ornamentals (reference 3).
Seed selection	Aster yellows phytoplasma is not seed-borne.

Management Option	Recommendations for Aster Yellows
Weed control	Weed hosts are the primary site where the disease overwinters. Control alternate weed host reservoirs including wild chicory, dandelion, fleabane, galinsoga, wild lettuce, plantain, common purslane, common ragweed, shepherd's purse, perennial sowthistle, Russian thistle, Canada thistle, and many others (reference 3). Ornamental hosts include gladiolus, poppy, chrysanthemum, phlox, and veronica.
Postharvest	Plow under lettuce fields immediately after harvest to reduce inoculum for future crops.
Note(s)	See aster leafhopper section (14.1) for management strategies of this important disease vector.

11.8 Lettuce Viruses, *Lettuce Mosaic Virus (LMV)*, *Cucumber Mosaic Virus (CMV)*, *Broadbean Wilt Virus (BBWV)*, transmitted by aphids

Time for concern: Aphids can carry inoculum into and from fields during the entire season, especially when plantings overlap.

Key characteristics: See factsheet (reference 61), photo (reference 62) and reference 50.

LMV: Symptoms of LMV vary considerably depending on the age of the plant at infection, the variety, and temperature. "Mother" plants, grown from infected seeds, show mosaic symptoms, stunting, and lack of development as early as the seedling stage. They serve as an initial source of virus which is then spread by aphids to other plants. Secondary infected plants show mosaic, leaf puckering, yellow-green mottling, and deep or accentuated serration of the leaf margins, with leaf lettuce showing these symptoms most notably. Leaf edges may turn brown and die. Holding young leaves up to the sun illuminates brown flecks in the smaller veins. Roll back of leaves is especially diagnostic in crisphead varieties.

CMV: Symptoms of CMV are similar to LMV, but the mosaic is more pronounced than LMV. Veinal browning and necrosis occurs when temperatures are in the mid-50's or lower. It is transmitted by aphids and mechanical wounding. **BBWV:** Symptoms are similar to those of LMV and CMV, but at lower field temperatures, the infected plants develop severe veinal necrosis. BBWV is also aphid transmitted in a non-persistent manner.

Relative risk: Viruses can be serious when they occur.

LMV: is one of the most common and damaging viruses causing lettuce to be discolored and fail to form a head.

CMV: is very difficult to control and damaging when present.

BBWV: can be serious in susceptible varieties.

Management Option	Recommendations for Viruses
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Site selection	Plant upwind from weedy border areas or previous lettuce plantings to reduce inoculum from these areas which may serve as virus reservoirs.
Crop rotation	**LMV**: This virus affects all types of lettuce and many other hosts including other greens, pea, spinach, aster, marigold, and zinnia. **CMV**: can infect more than 775 plant species including weeds, therefore is very difficult to control.
Resistant varieties	**LMV**: See resistant varieties in Section 6. **CMV**: resistant varieties are not known. **BBMV**: Some varieties are highly susceptible while others show high tolerance. Check with seed suppliers for resistance information.

Management Option	Recommendations for Viruses
Seed selection	**LMV** is seed-borne in all lettuce types, but not in endive, and infected seed is the most common route for LMV to be introduced into a field. Purchase lettuce seed designated *mosaic tolerance zero* (MTO), meaning a sample shows zero infested seeds in 30,000. **CMV**: is not seed-borne. **BBMV**: is not seed-borne.
Weed control	**LMV:** Many weeds are hosts including cheeseweed, chickweed, common groundsel, henbit, common lambsquarters, milkweed, ox tongue, purslane, scarlet pimpernel, shepherd's purse, sowbane, annual sow-thistle, and milk thistle. Controlling weed hosts in and around the field can slow the rate of infection. **CMV**: Perennial weed sources include hedge bindweed, white campion, common chickweed, corn cockle, burr cucumber, hairy galinsoga, common groundsel, horsenettle, jimsonweed, common lambsquarters, prickly lettuce, marshcress, common milkweed, pitted morning glory, tall morning glory, wild mustard, eastern black nightshade, field pennycress, prostrate pigweed, redroot pigweed, common purslane, wild radish, common ragweed, yellow rocket, shepherd's purse, annual sowthistle, corn speedwell, Canada thistle, and marsh yellowcress (reference 3). **BBWV**: The major perennial weed sources are broadleaf plantain and buckhorn plantain.
Postharvest	Plow under early lettuce fields immediately after harvest to reduce inoculum for later-planted crops.
Note(s)	This disease is transmitted by aphids in a non-persistent manner. The aphid acquires the virus from infected plants almost immediately. However, it is only able to infect healthy plants for a short time, usually a few days to a week. Suppressing aphid populations aids virus control. Oil sprays in the field and on weedy field borders can help to control viruses. See Section 14.2: *Aphids.*

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 11.8 Pesticides for Management of Viruses

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Organic JMS Stylet-Oil (paraffinic oil)	3 qt/100 gal water	0	4	?	Oil products effective against aphids in 2/5 trials. May reduce transmission of stylet-borne pathogens such as LMV and CMV.
PureSpray Green (white mineral oil)	0.75 gal/acre	up to day	4	?	See comment for Organic JMS Stylet-Oil

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

12. NEMATODES

12.1 Northern Root-Knot Nematode, *Meloidogyne hapla*

Time for concern: Seedling through harvest, but control measures are only effective before or at planting.

Key characteristics: This nematode spends most of its life living in the roots of its host, although the eggs and second stage juveniles can be found in the soil. Larvae travel through the soil in search of host roots, attaching most often near the root tip to feed. Root cells near the feeding site swell into visible galls (knots). Infected roots often exhibit extensive secondary root formation. Severely infected plants are stunted and exhibit wilting in the middle of hot and sunny days. See Cornell Bulletin (reference 64) and photo of root-knot nematode (reference 65).

Relative risk: Lettuce is the second most sensitive crop to root-knot nematode after carrots. Severely infected plants can be stunted and grow unevenly. Heads are often loose and small, making them unsuitable for some markets. Yield weights in experimental research plots showed a 26 percent reduction due to root-knot nematode damage (reference 64).

Management Options	Recommendations for Root-Knot Nematode
Scouting/thresholds	**Scouting:** Record the occurrence and severity of root-knot nematode infection on roots. **Threshold:** Damage threshold for lettuce is 2 eggs/cc of soil.
Site selection	Use a soil bioassay with lettuce to assess soil root-knot nematode infestation levels. Or, submit the soil sample(s) for nematode analysis at a public or private nematology lab (reference 63). See Section 4: *Field Selection* for more information or refer to the following Cornell publications for instructions: Soil Sampling For Plant Parasitic Nematodes (reference 66). Visual Assessment of Root-Knot Nematode Soil Infestation Levels Using a Lettuce Bioassay (ref 67).
Crop rotation	Root-knot nematodes can be reduced through crop rotation, but because of their large host range, are unlikely to be eliminated. Particularly sensitive hosts are carrot and onion, but also alfalfa, soybean and clover. Many grain crops are non-hosts including corn, barley, oats, annual ryegrass, rye grain, tall fescue, and wheat. These crops are effective at reducing root-knot nematode populations. Sudangrass is not only a non-host, but if incorporated as a chopped green residue, may further suppress populations.
Resistant varieties	Resistant varieties are not known.
Cover crops	Winter grain cover crops, such as winter rye and oat, are non-hosts for the northern root-knot nematode, thus they are effective at reducing the population. Biofumigant cover crops, 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 while the crop is growing, and exhibit their biofumigant effects when they are incorporated into the soil. Research suggests that Sudangrass hybrid 'Trudan 8' as well as selections of white clover and flax can be used effectively as a biofumigant to reduce nematode populations. Nemat is an arugula variety that functions as a trap crop, attracting nematodes but not enabling reproduction on its roots. Crucifer green manures are also effective as bio-fumigants. See Section 3: *Cover Crops* for more information.
Weed management	The following weeds host root-knot nematodes and should be controlled when possible: wild buckwheat, large crabgrass, dandelion, hairy galinsoga, common groundsel, prostrate knotweed, common lambsquarters, prickly lettuce, mallow, black medic, wild mustard, yellow nutsedge, field pennycress, field pepperweed, tumble pigweed, redroot pigweed, plantain, shepherd's purse, purslane, yellow rocket, speedwell, Canada thistle, and velvetleaf (references 3 and 64).
Cultural controls	Avoid moving soil from infested fields to uninfested fields on equipment and vehicles. Wash equipment after use in infested fields. Prevent surface run-off from infested fields.
Postharvest	If possible, plow under crop debris and plant a grain cover crop.

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
AzaGuard (azadirachtin)	15 fl oz/acre soil drench	0	4	?	Apply in sufficient amount of water to penetrate soil to a depth of 12".
DiTera DF (*Myrothecium verrucaria*)	13-100 lb/acre soil treatment	-	4	?	
Ecozin Plus 1.2% ME (azadirachtin)	15-30 fl oz/acre	0	4	?	Foliar spray and soil treatment.
MeloCon (*Paecilomyces lilacinus* str. 251)	2-4 lb/acre soil treatment	-	4	?	
Molt-X (azadirachtin)	15 oz/acre	0	4	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?-product for use on lettuce, but efficacy not known. [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. NONPATHOGENIC DISORDERS

Environmental factors can cause symptoms that appear to be diseases but are actually not caused by a pathogen or insect. See Section 6 for information on varieties resistant to the following disorders.

Table 13.1 Nonpathogenic Disorders of Lettuce

Disorder	Cause	Options
Tipburn	Tipburn is caused by insufficient calcium in plant tissue due to rapid plant growth, excessive fertilizer, or uneven water availability.	Plant resistant varieties. Irrigate with drip irrigation systems.
Poor stand	One cause is thermodormancy due to soil temperatures >80F. Other causes include planting too deep, old seed, and seed rots.	Irrigate when seeding in hot weather.
Bolting	High night temperatures during early summer and summer. Lettuce also bolts naturally when mature.	Plant heat tolerant varieties. Avoid summer plantings.
Russeting	Ethylene exposure during storage especially in crisphead varieties.	Do not store lettuce with ethylene producing crops.

14. 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 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 avoiding broad-spectrum insecticides. 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 an individual natural enemy species operating alone. Natural enemies need a reason to be present in the field, either a substantial pest population, alternative hosts, or a source of pollen or nectar, and may not respond to the 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 68) and A Guide to Natural Enemies in North America (reference 70).

Regulations

Organic farms must comply with all regulations regarding pesticide applications. See Section 10: *Using Organic Pesticides* 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: *Optimizing Pesticide Effectiveness* for more information.

Resources:

Biological Control: A Guide to Natural Enemies in North America (reference 70)
Resource Guide for Organic Insect and Disease Management (reference 2).
Natural Enemies of Vegetable Insect Pests (reference 68).

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 14.0.1 Pesticides for Insect Control in Organic Lettuce

CLASS OF COMPOUND Product name (*Active ingredient*)	Aphid	Leafhopper	Cabbage Looper	Tarnished Plant Bug
MICROBIAL				
Agree (*Bt aizawai*)			X	
Biobit (*Bt kurstaki str. ABTS-351*)			X	
Deliver (*Bt kurstaki*)			X	
DiPel DF (*Bt kurstaki*)			X	
Grandevo (*Chromobacterium subtsugae* str. PRAA4-1)	X		X	
Javelin WG (*Bt kurstaki*)			X	
Entrust (*spinosad*)			X	
Entrust SC (*spinosad*)			X	
PFR-97 20% WDG (*Isaria fumosorosea Apopka str. 97*)	X		X	X
Preferal(*Isaria fumosorosea Apopka str. 97*)	X		X	X
XenTari (*Bacillus thuringiensis*)			X	

CLASS OF COMPOUND Product name *(Active ingredient)*	**Aphid**	**Leafhopper**	**Cabbage Looper**	**Tarnished Plant Bug**
BOTANICAL				
Aza-Direct (*azadirachtin*)	**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, pyrethrins*)	**X**	**X**	**X**	**X**
BioLink Insect Repellant *(garlic juice)*	**X**	**X**	**X**	**X**
BioLink Insect & Bird Repellant *(garlic juice)*	**X**	**X**	**X**	**X**
BioRepel *(garlic oil)*	**X**	**X**		
Cedar Gard *(cedar oil)*		**X**		**X**
Ecozin Plus (*azadirachtin*)	**X**	**X**	**X**	**X**
Envirepel 20 *(garlic juice)*	**X**	**X**	**X**	
GC-Mite (*cottonseed, clove and garlic oils*)	**X**			
Molt-X *(azadirachtin)*	**X**	**X**	**X**	**X**
Neemix 4.5 (*azadirachtin*)	**X**	**X**	**X**	
Trilogy (*neem oil*)	**X**			
PyGanic EC 5.0 II (*pyrethrin*)	**X**	**X**	**X**	**X**
PyGanic EC 1.4 II(*pyrethrin*)	**X**	**X**	**X**	**X**
Garlic Barrier AG (*garlic juice*)	**X**	**X**	**X**	
SOAP				
DES-X (*insecticidal soap*)	**X**			**X**
M-Pede (*potassium salts of fatty acids*)	**X**	**X**		**X**
Safer Brand #567 Pyrethrin & Insecticidal Soap Concentrate II (*pyrethrins, potassium salts of fatty acids*)	**X**	**X**	**X**	**X**
OIL				
GrasRoots (*cinnamon oil*)	**X**			
Oleotrol-I *(soybean oil)*	**X**			
Omni Supreme Spray *(mineral oil)*	**X**	**X**	**X**	**X**
Organic JMS Stylet Oil (*paraffinic oil*)		**X**		
Glacial Spray Fluid (*mineral oil*)	**X**	**X**		
Organocide 3-in-1 *(sesame oil)*	**X**			
PureSpray Green (*petroleum oil*)	**X**	**X**	**X**	
SuffOil-X *(mineral oil)*	**X**	**X**	**X**	**X**
TriTek*(mineral oil)*	**X**	**X**	**X**	**X**
OTHER				
Ecotec (*rosemary and peppermint oil*)	**X**		**X**	**X**
Nuke Em *(citric acid)*	**X**			

CLASS OF COMPOUND Product name *(Active ingredient)*	Aphid	Leafhopper	Cabbage Looper	Tarnished Plant Bug
Sil-Matrix (*potassium silicate*)	X			

Active ingredient meets EPA criteria for acute toxicity to bees

14.1 Aphids primarily Green Peach Aphid, *Myzus persicae*

Time for concern: Mid-July through the end of the growing season.

Key characteristics: Adult green peach aphids come in a range of color including light green, pink, red, and dark brown. Adults can be winged or wingless depending on the time of year and the density of the aphid population. They range in length from 1/32 to 1/16 inch. Aphids are characterized by two cornicles or "tailpipes" on their abdomen. Their host range is wide including weeds, ornamentals, and other vegetable crops. See photos and more information about aphids in the Ontario fact sheet (reference 72).

Relative risk: This annual, but sporadic, pest primarily serves as a vector of damaging virus diseases although large populations can contaminate the crop at harvest.

Management Options	Recommendations for Aphids
Scouting/thresholds	**Scouting:** Scout plantings weekly. Dispersal flights of winged adult aphids can be monitored using yellow sticky boards placed along the field borders. Monitor field populations by visually inspecting 30 plants, checking undersides of leaves and tender new growth. **Thresholds:** Thresholds depend on market tolerance. Community supported agriculture (CSA) outlets are normally more tolerant than the general market.
Resistant varieties	Resistant varieties are not available.
Cultural controls	Row covers can protect lettuce plants from infestation. Cover rows during planting with fine netting or floating row covers to protect them from egg-laying. Hoops may be needed to support the netting to prevent it from damaging the crop. Anchor the edges of the row cover to prevent insects from entering at the edges. Row covers may be left on until harvest.
Biological controls	Numerous natural enemies prey on aphids and can reduce the overall populations. However, some natural enemies can also be contaminants if present in the harvested product. Ladybird beetle larvae, lacewing larvae, cecidomyid fly larvae, syrphid fly larvae, and parasitic wasps are common parasites of aphids (reference 72). Choose practices that preserve these insects. See reference 68 or 70 for more information on natural enemies.
Chemical controls	Spraying aphids within a field will not eliminate the introduction of mosaic viruses borne by aphids immigrating from sources outside of the field, but may reduce virus spread from plant to plant within the field.
Postharvest	Plow under or remove all lettuce plant debris in the field immediately after harvest.
Note(s)	New York State lettuce entering the export market must be kept clean of aphids and other insect contaminants.

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 14.1 Pesticides for Management of Aphids

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Azadirachtin based products effective in 4/7 trials against the green peach aphid. Up to 3.5 pts per acre can be used under extreme pest pressure.
AzaGuard (azadirachtin)	10-16 fl oz/acre	0	4	1	Azadirachtin based products effective in 4/7 trials against the green peach aphid. Apply with OMRI approved spray oil.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	1	Azadirachtin based products effective in 4/7 trials against the green peach aphid.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for AzaMax
Azatrol-EC (azadirachtin)	0.24-0.96 fl/ 1000 ft^2	0	4	1	See comment for AzaMax
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	1	See comment for AzaMax
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioRepel (garlic oil)	1 part BioRepel with 100 parts water	-	-	2	25(b) pesticide. Oil products effective in 2/5 trials.
DES-X (insecticidal soap)	2% solution sprayed at 75-200 gallons/acre	1/2	12	?	
Ecotec (Rosemary oil, Peppermint oil)	1-4 pts/acre	-	-	?	25(b) pesticide.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	See comment for AzaMax Crops can be harvested as soon as spray has dried. May slow feeding and affect nymphal development.
Envirepel 20 (garlic juice)	10-32 fl oz/A	-	-	?	25(b) pesticide.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide.
GC-Mite (garlic oil, clove oil, cottonseed oil)	1 gal/100 gal water	-	-	2	25(b) pesticide. Oil products effective in 2/5 trials. Check compatibility by spraying a small number of plants.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	2	Oil products effective in 2/5 trials. See label for specific application volumes and equipment.
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 AzaMax

Table 14.1 Pesticides for Management of Aphids

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
M-Pede (insecticidal soap)	1-2% solution	0	12	3	Soap based products effective in 0/9 trials against green peach aphid. Tank mix M-Pede with a labeled companion insecticide for green peach aphid control.
Neemix 4.5 (azadirachtin)	5-7 fl oz/acre	0	4	1	See comment for AzaMax. May slow feeding and affect nymphal development. Only labeled for green peach aphid.
Nuke Em (citric acid)	1 fl oz/ 31 fl ozwater to 2 fl oz/30 fl oz water	-	-	?	
Oleotrol-I Bio-Insecticide Concentrate (soybean oil)	43-45 fl oz/100 gal water	-	-	2	25(b) pesticide. Oil products effective in 2/5 trials.
Omni Supreme Spray (mineral oil)	1-2 gal/acre	-	12	2	Oil products effective in 2/5 trials. Use in combination with other insecticides registered for use on lettuce.
Organocide (sesame oil)	1-2 gal/100 gal water	0	0	2	25(b) pesticide. Oil products effective in 2/5 trials.
PFR-97 20% WDG (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	Repeat applications at 3-10 day intervals as needed to maintain control.
Preferal (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	2	Oil products effective in 2/5 trials.
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	?	
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water applied at 1 gal mix/700 sq ft	until dry	12	?	
Sil-Matrix (potassium silicate)	0.5-1% solution	0	4	?	Only provides suppression of aphids.
SuffOil-X (aliphatic petroleum solvent)	1-2 gal/100 gal water	up to day	4	2	Oil products effective in 2/5 trials. Do not mix with sulfur products.
Trilogy (neem oil)	0.5-1% solution	Up to day	4	?	Apply no more than 2 gallons of Trilogy per acre per application. May slow feeding and affect nymphal development. Bee Hazard. This product is toxic to bees exposed to direct contact
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	2	Oil products effective in 2/5 trials. Apply as needed.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest. Active ingredient meets EPA criteria for acute toxicity to bees

14.2 Aster Leafhopper, *Macrosteles quadrilineatus*

Time for concern: Mid-June through the end of the growing season.

Key characteristics: Aster leafhoppers transmit the pathogen that causes aster yellows disease. This pest does not appear to overwinter in New York and early spring populations largely migrate from Gulf Coast states and other southern areas. See University of Minnesota fact sheet (reference 71). Aster leafhopper has a wide host range feeding on over 100 plant species although preferring cereals and grasses.

Relative risk: Aster leafhopper itself only causes minimal damage to lettuce, but is more importantly a vector for aster yellows disease. See Section 11.7: *Aster yellows*.

Management Options	Recommendations for Aster Leafhoppers
Scouting/thresholds	Thresholds have not been established for organic production.
Crop rotation	Crop rotation is ineffective due to the leafhopper's ability to travel long distances.
Resistant varieties	Resistant varieties are not available.
Weed control	Control both broadleaf and grassy weeds near lettuce plantings. See Section 11.7: *Aster Yellows* for more information on alternate host weeds. Where possible, mow headlands around fields.
Mechanical controls	Row covers protect against adult leafhoppers.
Traps	Do not place yellow or white sticky traps directly within lettuce fields since they tend to attract migrating adult leafhoppers.
Note(s)	Reducing aster yellows inoculum is more critical than controlling leafhopper populations since the insect rarely causes direct feeding damage, but instead spreads inoculum throughout the lettuce fields.

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 14.2 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	?	Up to 3.5 pts per acre can be used under extreme pest pressure.
AzaGuard (azadirachtin)	10-16 fl.oz./acre	0	4	?	Apply with OMRI approved spray oil.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	?	
Azatrol-EC (azadirachtin)	0.24-0.96 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. Repellent.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioRepel (garlic oil)	1 part BioRepel with 100 parts water	-	-	?	25(b) pesticide.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
Ecozin Plus 1.2% ME	15-30 oz/acre	0	4	?	May affect nymphal development.

Table 14.2 Pesticides for Management of Aster Leafhopper					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2](Days)	REI (Hours)	Efficacy	Comments
(azadirachtin)					Crops can be harvested as soon as spray has dried.
Envirepel 20 (garlic juice)	10-32 fl oz/A	-	-	?	25(b) pesticide. Repellent.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide. Repellent.
Glacial Spray Fluid (mineral oil)	0.75-1 gal/100 gal water	up to day	4	?	See label for specific application volumes and equipment.
Molt-X (azadirachtin)	10 oz/acre	0	4	?	
M-Pede (insecticidal soap)	0.25-2% v/v solution	0	12	3	Not effective in 1/1 trial against potato leafhopper. Spray material must contact pest to be effective.
Neemix 4.5 (azadirachtin)	7-16 fl oz/acre	0	4	?	May affect nymphal development.
Omni Supreme Spray (mineral oil)	1-2 gal/acre	-	12	?	Use in combination with other insecticides registered for use on lettuce.
Organic JMS Stylet Oil	3-6 qt/100 gal water	0	4		
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	4	?	
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz/acre	until dry	12	1	Pyrethrin based products effective in 2/3 trials against leafhopper species.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	-	12	1	See comment for PyGanic EC 1.4 II.
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal water applied at 1 gal mix/700 sq ft	until dry	12	1	See comment for PyGanic EC 1.4 II.
SuffOil-X (aliphatic petroleum solvent)	1-2 gal/100 gal water	up to day	4	?	Do not mix with sulfur products.
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	?	Apply as needed.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.
Active ingredient meets EPA criteria for acute toxicity to bees

14.3 Cabbage Looper, *Trichoplusia ni*

Time for concern: August 1 through harvest. Cold, wet weather conditions will reduce cabbage looper populations. Favorable weather fronts from the south may suddenly increase populations.

Key characteristics: Because adults are nocturnal, the gray, non-descript moths are seldom seen. Adult moths are mottled gray-brown, 3/4 inch long, with a distinct silver-white round mark on the wing. White, round eggs, the size of a pinhead, are laid on the undersides of leaves. Larvae hatch in less than a week and will feed on lettuce for 2 to 4 weeks, chewing ragged holes in the leaves. Larvae are up to 1 ½ inches long, light green with white stripes along each side of the body and can be distinguished by the looping movement they use to travel. See Cornell factsheet (reference 73), University of Illinois photos (reference 74), and references 4 and 75.

Relative risk: Because cabbage looper does not overwinter in New York, infestations are variable and depend on weather fronts to move them in from areas further south. Both larvae and associated feces are considered contaminants of the crop at harvest. Loopers are mainly a concern for fall-harvested plantings.

Management Option	Recommendation for Cabbage Looper
Crop rotation	Since cabbage looper does not overwinter in New York, crop rotation will not help manage this pest.
Planting methods	Cabbage loopers don't reach significant levels until late July or early August. Early season lettuce will escape most cabbage looper damage.
Scouting/thresholds	Thresholds and scouting techniques have not been developed for organic lettuce.
Traps	Bucket-type pheromone or UV light traps can be used to monitor moth flight. See reference 76, Pheromone Traps for Insect Pest Management, for more information.
Weed control	Cabbage loopers have many broadleaf hosts so weed control may be helpful in reducing field attractiveness for egg laying by dispersing moths.
Cultural controls	Lettuce plantings that are harvested early in the season usually avoid cabbage looper damage.
Biological controls	Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. See A Guide to Natural Enemies in North America (reference 70) for identification of natural enemies.
Floating row covers	For smaller plantings, row covers can be used as a barrier to egg-laying adults, provided they are installed prior to migration of adult moths into the area. Row covers can remain in place until harvest. See Cornell insect traps and barriers factsheet (reference 77) for more on row covers.
Vacuum/leaf blower	Larvae can be vacuumed from leaves using a retail or commercial-duty leaf blower operated for suction.

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 14.3 Pesticides for Management of Cabbage Looper

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
Agree WG (*Bacillus thuringiensis*)	0.5-2 lb/acre	up to day	4	1	Bt products effective in 6/7 trials. Good coverage is essential.
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Up to 3.5 pts per acre can be used under extreme pest pressure. Azadirachtin based products effective in 2/4 trials.
AzaGuard (azadirachtin)	8-16 fl.oz./acre	0	4	1	Apply with OMRI approved spray oil. Azadirachtin based products effective in 2/4 trials.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	1	Azadirachtin based products effective in 2/4 trials.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for AzaMax.
Azatrol-EC (azadirachtin)	0.19-0.96 fl	0	4	1	See comment for AzaMax.

Table 14.3 Pesticides for Management of Cabbage Looper

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
	oz/1000 ft^2				
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	1	See comment for AzaMax.
Biobit HP *(Bacillus thuringinensis* subsp. Kurstaki)	0.5-1 lb/acre	0	4	1	Bt products effective in 6/7 trials.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.
Deliver (*Bacillus thuringinen*sis subsp. Kurstaki)	0.25-1.5 lb/acre	0	4	1	Bt products effective in 6/7 trials.
Dipel DF (*Bacillus thuringinensis* subsp. Kurstaki)	0.5-2 lb/acre	0	4	1	Bt products effective in 6/7 trials.
Ecotec (rosemary oil, Peppermint oil)	1-4 pts/acre	-	-	?	25(b) pesticide.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	Crops can be harvested as soon as spray has dried.Azadirachtin based products effective in 2/4 trials.Will not control adults.
Entrust (spinosad)	1-2 oz/acre	1	4	1	Spinosad products effective in 41/47 trials against caterpillar species including cabbage looper.
Entrust SC (spinosad)	3-6 fl.oz./acre	1	4	1	See comment for Entrust.
Envirepel 20 (garlic juice)	10-32 fl oz/A	-	-	?	25(b) pesticide. Repellent.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide. Repellent.
Grandevo (*Chromobacterium subtsugae* str. PRAA4-1)	1-3 lb/acre	0	4	?	
Javelin WG (*Bacillus thuringinensis* subsp. Kurstaki)	0.12-1.5 lb/acre	0	4	1	Bt products effective in 6/7 trials.
Molt-X (azadirachtin)	8 oz/acre	0	4	1	See comment for AzaMax.
Neemix 4.5 (azadirachtin)	7-16 fl oz/acre	0	4	1	See comment for AzaMax.
Omni Supreme Spray (mineral oil)	1-2 gal/acre	-	12	?	Use in combination with other insecticides registered for use on lettuce.
PureSpray Green (white mineral oil)	0.75-1.5 gal/acre	up to day	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	?	
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal of water applied at 1 gal mix/700 sq ft	until dry	12	?	
SuffOil-X (aliphatic petroleum solvent)	1-2 gal/100 gal water	up to day	4	?	Do not mix with sulfur products.

Table 14.3 Pesticides for Management of Cabbage Looper					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	?	Apply as needed.
XenTari (Bacillus thuringiensis, var. aizawai)	0.5-1.5 lb/acre	0	4	1	Bt products effective in 6/7 trials.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label. Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.
Active ingredient meets EPA criteria for acute toxicity to bees

14.4 Tarnished Plant Bug, *Lygus lineolaris*

Time for concern: Throughout the season

Key characteristics: The tarnished plant bug (TPB) introduces a plant toxin while feeding that causes brown lesions along the midrib. After overwintering as adults in plant debris, they lay eggs in early spring which hatch in about a week and become adults in approximately 30 days. There are normally 3 generations per season, peaking from mid-June to mid-July. Feeding by the nymphs is the main source of damage. See Cornell fact sheet with photos (reference 78) and Ontario photo of damage to lettuce (reference 79).

Relative Risk: Brown spots on the mid-rib reduce marketability.

Management Options	Recommendations for Tarnished Plant Bug
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production.
Crop rotation	Crop rotation is not a useful management tool since TPB is very mobile and has many hosts including most legumes, flowering buckwheat, pigweed, brassicas, a number of plants in the Rosaceae family, and many more.
Weed control	Control weeds and keep headlands mowed to prevent TPB buildup.
Cultural controls	Row covers may raise temperatures too much to be useful for summer lettuce crops. TPB can harbor in cover crops, neighboring plantings, or weeds surrounding fields and, when mowed or harvested, will then move to lettuce fields. Legume cover crops, such as hairy vetch, can lure TPB out of lettuce fields or prevent them from entering. Managing TPBs requires an approach to limit their overall population and movement throughout the farm. Be aware of high populations that can quickly move from field to field. Consider strip cutting of crops harboring large populations of TPB.
Biological controls	Natural enemies of the TPB include the big-eyed bug (*Geocoris punctipes*), and various wasps (*Peristenus digoneutis*, *Leiophron uniformis, Anaphes ovijentatus*, and *Peristenus pallipes*). *Peristenus digoneutis* is non-native but is becoming established as a biological control in some areas. See reference 68 and 70 for more information on natural enemies.
Traps	Yellow and white sticky ribbons may reduce adult populations.
Note(s)	Most organic pesticides have not been effective against TPB.

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 14.4 Pesticides for Management of Tarnished Plant Bug

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI[2] (Days)	REI (Hours)	Efficacy	Comments
AzaGuard (azadirachtin)	10-16 fl oz/acre	0	4	3	Apply with OMRI approved spray oil. Azadirachtin based products effective in 0/2 trials.
AzaMax (azadirachtin)	1.33 fl oz/1000 ft^2	0	4	3	Azadirachtin based products effective in 0/2 trials.
AzaSol (azadirachtin)	6 oz/acre	-	4	3	See comment for AzaMax. Nymphs only.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/1000 ft^2	0	4	3	See comment for AzaMax.
Azera (azadirachtin, pyrethrins)	1-3.5 pts/acre	-	12	3	See comment for AzaMax.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide.
DES-X (insecticidal soap)	2% solution sprayed at 75-200 gallons/acre	1/2	12	?	
Ecotec (Rosemary oil, Peppermint oil)	1-4 pts/acre	-	-	?	25(b) pesticide.
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	3	Crops can be harvested as soon as spray has dried. Will not control adults. Azadirachtin based products effective in 0/2 trials.
Molt-X (azadirachtin)	10 oz/acre	0	4	3	See comment for AzaMax.
M-Pede (insecticidal soap)	0.25-2% v/v solution	0	12	?	Spray material must contact pest to be effective. Activity of this product is directly related to the solution concentration and contact with the pest, not the amount of product applied per acre.
Omni Supreme Spray (mineral oil)	1-2 gal/acre	-	12	?	Use in combination with other insecticides registered for use on lettuce.
PFR-97 20% WDG (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	Repeat applications at 3-10 day intervals as needed to maintain control.
Preferal (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	
PyGanic EC 1.4 II (pyrethrins)	16-64 fl.oz./acre	until dry	12	3	Pyrethrin based products effective in 0/1 trial.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl.oz./acre	-	12	3	Pyrethrin based products effective in 0/1 trial.

Table 14.4 Pesticides for Management of Tarnished Plant Bug					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2] (Days)**	**REI (Hours)**	**Efficacy**	**Comments**
Safer Brand #567 II (potassium laurate, pyrethrins)	6.4 oz/ gal of water applied at 1 gal mix/700 sq ft	until dry	12	?	
SuffOil-X (aliphatic petroleum solvent)	1-2 gal/100 gal water	up to day	4	?	Do not mix with sulfur products.
TriTek (mineral oil)	1-2 gal/100 gal water	up to day	4	?	Apply as needed.

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, ?- product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.
Active ingredient meets EPA criteria for acute toxicity to bees

15. Slugs

Time for concern: Early spring and fall or when conditions are moist.

Key characteristics: Adult slugs are between one and two inches in length. Slugs can overwinter at any stage of development. Although slugs cannot survive prolonged subzero temperatures or desiccation, the burrows of small mammals and worms provide shelter. Slugs begin to move, hatch, feed, and lay eggs in the spring when temperatures are consistently above 40°F. There is often little or no slug activity in the field during periods of dry weather; however, there may be extensive feeding in damp areas or during wet years. Slug damage is often worse in fields where organic matter is decomposing. See Cornell fact sheet(reference 80).

Relative risk: Contamination by, and damage from, slugs in the marketable product is the biggest concern, although slugs can also injure young seedlings.

Management Options	Recommendations for Slugs
Scouting/thresholds	Scouting and thresholds for slugs have not been established for organic production.
Weed Control	Control weeds to deprive slugs of protected resting sites.
Cultural Controls	Practices that dry the soil surface (e.g. conventional tillage and weed control) will reduce slug populations. Fields with higher levels of decomposing organic matter are more prone to slug damage.

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.

Pesticides for Management of Slugs					
Class of Compounds Product Name (Active Ingredient)	**Product Rate**	**PHI[2](Days)**	**REI (Hours)**	**Efficacy**	**Comments**
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.

Pesticides for Management of Slugs					
Bug-N-Sluggo (spinosad, iron phosphate)	20-44 lb/acre soil treatment	1	4	?	
Sluggo AG (iron phosphate)	24-44 lb/acre soil treatment	-	0	?	Scatter bait around perimeter of plantings to provide a barrier from entry. If slugs are inside the rows, scatter bait on the soil around and between the rows.
Sluggo Slug and Snail Bait (iron phosphate)	20-44 lb/acre soil treatment	0	0	?	

PHI = pre-harvest interval, REI = restricted entry interval. - = pre-harvest interval isn't specified on label.
Efficacy: 1- effective in half or more of recent university trials, 2- effective in less than half of recent university trials, 3-not effective in any known trials, X-product for use on lettuce, but efficacy not known. [2]Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.
Active ingredient meets EPA criteria for acute toxicity to bees

16. Pesticides and Abbreviations Mentioned in this Publication

Table 16.1 Insecticides and Molluscides

TRADE NAME	ACTIVE INGREDIENTS	EPA REG. NO.
Agree	*Bacillus thuringiensis subsp. aizawai str.*GC-91	70051-47
Aza-Direct	*azadirachtin*	71908-1-10163
AzaGuard	*azadirachtin*	70299-17
Azamax	*azadirachtin*	71908-1-81268
AzaSol	*azadirachtin*	81899-4
Azatrol EC	*azadirachtin*	2217-836
Azera	*azadirachtin, pyrethrins*	1021-1872
Biobit HP	*Bacillus thuringiensis subsp. kurstaki*	73049-54
BioLink Insect Repellant	*garlic juice*	Exempt - 25(b) pesticide
BioLink Insect & Bird Repellant	*garlic juice*	Exempt - 25(b) pesticide
BioRepel	*garlic oil*	Exempt - 25(b) pesticide
Bug-N-Sluggo Insect, Slug and Snail Bait	*iron phosphate and spinosad*	67702-24-70051
Cedar Gard	*cedar oil*	Exempt - 25(b) pesticide
Deliver	*Bacillus thuringiensis subsp. kurstaki*	70051-69
DES-X	*insecticidal soap*	67702-22-70051
DiPel DF	*Bacillus thuringiensis subsp. kurstaki*	73049-39
Ecotec	*rosemary and peppermint oil*	Exempt - 25(b) pesticide
Ecozin Plus	*azadirachtin*	5481-559
Entrust	*spinosad*	62719-282
Entrust SC	*spinosad*	62719-621
Envirepel 20	*garlic juice*	Exempt - 25(b) pesticide
GC-Mite	*cottonseed, clove and garlic oils*	Exempt - 25(b) pesticide
Garlic Barrier AG	*garlic juice*	Exempt - 25(b) pesticide
Glacial Spray Fluid	*mineral oil*	34704-849
Grandevo	*Chromobacterium subtsugae str. PRAA4-1*	84059-17
GrasRoots	*cinnamon oil*	Exempt - 25(b) pesticide
Javelin WG	*Bacillus thuringiensis subsp. kurstaki*	70051-66
M-Pede	*potassium salts of fatty acids*	10163-324
Molt-X	*azadirachtin*	68539-11
Neemix 4.5	*azadirachtin*	70051-9
Nuke Em	*citric acid*	Exempt - 25(b) pesticide
Oleotrol-I	*soybean oil*	Exempt - 25(b) pesticide
Omni Supreme Spray	*mineral oil*	5905-368

Table 16.1 Insecticides and Molluscides

TRADE NAME	ACTIVE INGREDIENTS	EPA REG. NO.
Organic JMS Stylet-Oil	*paraffinic oil*	65564-1
Organocide 3-in-1	*sesame oil*	Exempt - 25(b) pesticide
PFR-97 20% WDG	*Isaria fumosorosea Apopka str. 97*	70051-19
Preferal	*Isaria fumosorosea Apopka str. 97*	70051-19-67690
PureSpray Green	*petroleum oil*	69526-9
PyGanic EC 1.4 II	*pyrethrin*	1021-1771
PyGanic EC 5.0 II	*pyrethrin*	1021-1772
Safer Brand #567 Pyrethrin & Insecticidal Soap Concentrate II	*pyrethrins + potassium salts of fatty acids*	59913-9
Sil-Matrix	*potassium silicate*	82100-1
Sluggo AG	*iron phosphate*	67702-3-54705
Sluggo Slug and Snail Bait	*iron phosphate*	67702-3-70051
SuffOil-X	*mineral oil*	48813-1-68539
Trilogy	*neem oil*	70051-2
TriTek	*mineral oil*	48813-1
XenTari	*Bacillus thuringiensis subsp. aizawai*	73049-40

Active ingredient meets EPA criteria for acute toxicity to bees

Table 16.2 Fungicides and Nematicides

TRADE NAME	ACTIVE INGREDIENTS	EPA REG. NO.
Actinovate AG	*Streptomyces lydicus WYEC 108*)	73314-1
Actinovate STP Fungicide	*Streptomyces lydicus WYEC 108*	73314-4
Agricure	*potassium bicarbonate*	70870-1
AzaGuard	*Azadirachtin*	70299-17
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
ChampION++	*copper hydroxide*	55146-115
Contans WG	*Coniothyrium minitans*	72444-1
Cueva Fungicide Concentrate	*copper octanoate*	67702-2-70051
DiTera DF	*Myrothecium verrucaria str. AARC-0255*	73049-67
Double Nickel 55 Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-108
Double Nickel LC Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-107
Ecozin Plus	*azadirachtin*	5481-559
*GreenClean PRO	*sodium carbonate peroxyhydrate*	70299-15
MeloCon WG Biological Nematicide	*Paecilomyces lilacinus str. 251*	72444-2
MilStop	*potassium bicarbonate*	70870-1-68539
Mycostop Biofungicide	*Streptomyces griseoviridis*	64137-5
Mycostop Mix	*Streptomyces griseoviridis*	64137-9
Nordox 75 WG	*copper hydroxide*	48142-4
Nu-Cop 50DF	*cupric hydroxide*	45002-4
Nu-Cop 50 WP	*cupric hydroxide*	45002-7
Nu-Cop HB	*cupric hydroxide*	42750-132
Optiva	*Bacillus subtilis str. QST 713*	69592-26
Organic JMS Stylet Oil	*paraffinic oil*	65564-1
Organocide 3-in-1	*sesame oil*	Exempt – 25(b) pesticide
OxiDate 2.0	*hydrogen dioxide, peroxyacetic acid*	70299-12
PERpose Plus	*hydrogen peroxide/dioxide*	86729-1
Prestop Biofungicide	*Gliocladium catenulatum str. J1446*	64137-11
Regalia Biofungicide	*Reynoutria sachalinensis*	84059-3
RootShield WP	*Trichoderma harzianum Rifai str. KRL-AG2*	68539-7
RootShield PLUS+ WP	*Trichoderma harzianum str. T-22, Trichoderma*	68539-9

Table 16.2 Fungicides and Nematicides

TRADE NAME	ACTIVE INGREDIENTS	EPA REG. NO.
	virens str. G-41	
RootShield Granules	*Trichoderma harzianum str. T-22*	68539-3
RootShield PLUS+ Granules	*Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*	68539-10
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*	70051-3
Taegro Biofungicide	*Bacillus subtilis var. amyloliquefaciens str. FZB24*	70127-5
Taegro ECO	*Bacillus subtilis var. amyloliquefaciens str. FZB24*	70127-5-100
TerraClean 5.0	*hydrogen dioxide, peroxyacetic acid*	70299-13
Trilogy	*neem oil*	70051-2

* Restricted-use pesticide in New York State; may be purchased and used only by certified applicators

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 Used in This Publication

A	acre	NI	no information
ASO	aqueous suspension-organic	NOP	National Organic Program
EC	emulsifiable concentrate	OMRI	Organic Materials Review Institute
G	granular	P	phosphorus
HC	high concentrate	REI	restricted-entry interval
K	potassium	WP	wettable powder
L	liquid	WPS	Worker Protection Standard
N	nitrogen	WG, WDG	water dispersible granular

17. References and Resources

Links checked May 1, 2016

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