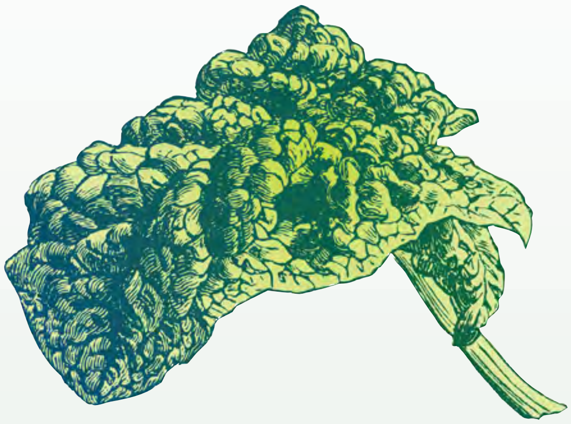
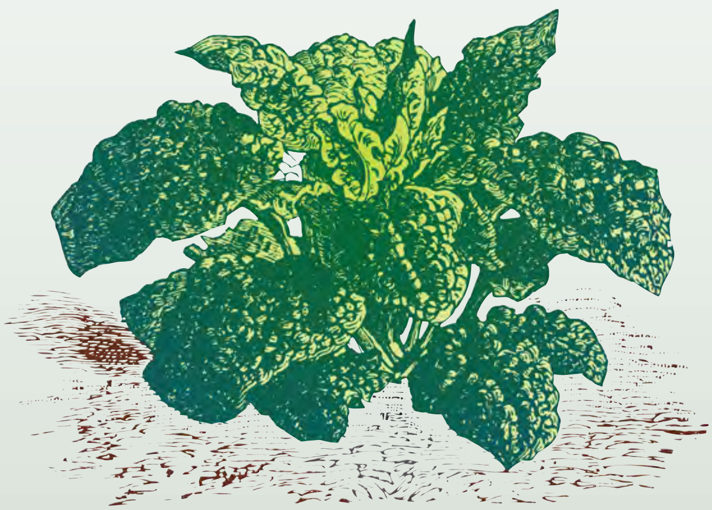
2014

Production Guide for Organic Spinach





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Integrated Pest Management

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2014 Production Guide for Organic Spinach

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2014 Organic Guides Disclaimer

Due to a funding gap, the 2014 updates to the Organic Guides were not comprehensive. We attempted to remove products that are no longer OMRI listed, and pesticide information has been reviewed for label accuracy and compliance with New York State Department of Environmental Conservation regulations. While products listed in the guides should always be checked to be sure they are NOP compliant, it is particularly important to do so this year. Products added to the OMRI list in the past year were not added to the guides and links were not updated. We hope to be able to provide comprehensive updates for 2015 and 2016.

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

Every effort has been made to provide correct, complete, and up-to-date pest management information for New York State at the time this publication was released for printing (July 2014). Changes in pesticide registrations and regulations, occurring after publication are available in county Cornell Cooperative Extension offices or from the Pesticide Management Education Program web site (*http://pmep.cce.cornell.edu*). Trade names used herein are for convenience only. No endorsement of products in intended, nor is criticism of unnamed products implied.

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

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

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INTRODUCTION

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

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

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

1. General Organic Management Practices

1.1 Organic Certification

To use a certified organic label, farming operations grossing more than $5,000 per year in organic products must be certified by a U.S. Department of Agriculture National Organic Program (NOP) accredited certifying agency. The choice of certifier may be dictated by the processor or by the target market. A list of accredited certifiers (Reference 11) operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Resource Center web page (Reference 12). See more certification and regulatory details under Section 4.1 *Certification Requirements* and Section 10: *Using Organic Pesticides.*

1.2 Organic Farm Plan

An organic farm plan is central to the certification process. The farm plan 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 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 to be successful. Certifying organizations may be able to provide a template for the farm plan. The following description of the farm plan is from the National Organic Program (NOP) web site:

The Organic Food Production Act of 1990 (OFPA or Act) requires that all crop, wild crop, livestock, and handling operations requiring certification submit an organic system plan to their certifying agent and, where applicable, the State Organic Program (SOP). The organic system plan is a detailed description of how an operation will achieve, document, and sustain compliance with all applicable provisions in the OFPA and these regulations. The certifying agent must concur that the proposed organic system plan fulfills the requirements of subpart C, and any subsequent modification of the organic plan by the producer or handler must receive the approval of the certifying agent.

More details may be found at the Agricultural Marketing Service's National Organic Program website (Reference 13). The National Sustainable Agriculture Information Service, (formerly ATTRA), has produced a guide to organic certification that includes templates for developing an organic farm plan (Reference 16). The Rodale Institute has also developed resources for transitioning to organic and developing an organic farm plan (Reference 17).

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 on the soil and on the root surface. Newly incorporated organic matter, however, can reduce seed germination and increase damping-off.

Rotating between crop families can help prevent the buildup of diseases and nematodes that overwinter in the soil. Rotation with a grain crop, preferably a sod 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. 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 19). For additional information, refer to the Cornell Soil Health website (Reference 20).

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 conventional untreated 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 21).

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

Special considerations for spinach

Both *Pythium* and *Rhizoctonia* are good at colonizing on incorporated crop debris and green manures, especially under wet soil conditions. High populations of *Pythium* and *Rhizoctonia* will affect emergence and stand establishment. Plan several weeks between incorporating green manure and planting spinach to allow for decomposition and for equilibrium to be established among soil organisms.

Grow winter-killed cover crops such as oats and peas before spinach to simplify seedbed preparation. Spinach can also be fall planted after a fall incorporated cover crop, such as buckwheat or sorghum-sudangrass, and overwintered for an early spring harvest (See Section 5: *Weed Management* and Section 7: *Planting*).

3.2 Legumes

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

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

Special consideration for spinach

Legume cover crops are good hosts to *Pythium* and *Rhizoctonia*. Do not plant spinach after a legume cover crop in a field with a known history of damage by these pathogens.

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 as they decompose. If incorporated, allow three weeks or more for decomposition prior to planting to avoid the negative impact on stand establishment from actively decomposing material. Three weeks might not be enough if soils are very cold. Grain crops are the best choice as cover or rotational crops before planting spinach.

3.4 Combining Legumes and Non-legumes

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

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 brands 199 and Nemat).

Attend to the cultural requirements of the cover crops to maximize growth. Fertilizer applied to the cover crops will be taken up and then returned to the soil for use by the cash crop after the cover crop is incorporated. Biofumigant cover crops like mustard should be allowed to grow to their full size, normally several weeks after flowering starts, but incorporated before the seeds become brown and hard indicating they are mature. To minimize loss of biofumigant, finely chop the tissue early in the day when temperatures are low. Incorporate immediately by tilling, preferably with a second tractor following the chopper. Lightly seal the soil surface using a culti-packer and/or 1/2 inch of irrigation or rain water to help trap the volatiles and prolong their persistence in the soil. Wait at least two weeks before planting a subsequent crop to reduce the potential for the breakdown products to harm the crop, also known as phytotoxicity. Scratching the soil surface before planting will release remaining biofumigant. This biofumigant effect is not predictable or consistent. The levels of the active compounds and suppressiveness can vary by season, cover crop variety, maturity at incorporation, amount of biomass, fineness of chopping, how quickly the tissue is incorporated, soil microbial diversity, soil tilth, and microbe population density.

Resources

Cover Crops for Vegetable Growers: Decision Tool (Reference 21).

Northeast Cover Crops Handbook (Reference 22).

Cover Crops for Vegetable Production in the Northeast (Reference 23).

Crop Rotation on Organic Farms: A Planning Manual (Reference 24).

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

Species	Planting Dates	Life Cycle	Cold Hardiness Zone	Tolerances: Heat	Tolerances: Drought	Tolerances: Shade	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
CLOVERS											
Alsike	April-May	Biennial/ Perennial	4	5	5	6	6.3	Clay to silt	4-10	60-119	+Endures waterlogged soils & greater pH range than most clovers
Berseem	Early spring	Summer annual/ Winter annual[b]	7	6-7	7-8	5	6.5-7.5	Loam to silt	9-25	50-95	+Good full-season annual cover crop
Crimson	Spring	Summer annual/ Winter annual[b]	6	5	3	7	5.0-7.0	Most if well-drained	9-40	70-130	+Quick cover +Good choice for overseeding (shade tolerant) + Sometimes hardy to zone 5.
Red	Very early spring or late summer	Short-lived perennial	4	4	4	6	6.2-7.0	Loam to clay	7-18	100-110	+Strong taproot, good heavy soil conditioner +Good choice for overseeding (shade tolerant)
White	Very early spring or late summer	Long-lived perennial	4	6	7	8	6.2-7.0	Loam to clay	6-14	≤130	+Good low maintenance living cover +Low growing +Hardy under wide range of conditions
SWEET CLOVERS											
Annual White	Very early spring	Summer annual[b]	NFT	6-7	6-7	6	6.5-7.2	Most	15-30	70-90	+Good warm weather smother & catch crop +Rapid grower +High biomass producer
Biennial White and Yellow	Early spring-late summer	Biennial	4	6	7-8	4	6.5-7.5	Most	9-20	90-170	+Deep taproot breaks up compacted soils & recycles nutrients +Good catch crop +High biomass producer
OTHER LEGUMES											
Cowpeas	Late spring-late summer	Summer annual[b]	NFT	9	8	6	5.5-6.5	Sandy loam to loam	25-120	130	+Rapid hot weather growth
Fava Beans	April-May or July-August	Summer annual[b]	8	3	4	NI	5.5-7.3	Loam to silty clay	80-170 small seed 70-300 lg seed	71-220	+Strong taproot, good conditioner for compacted soils + Excellent cover & producer in cold soils +Efficient N-fixer
Hairy Vetch	Late August-early Sept.	Summer annual/ Winter annual	4	3	7	5	6.0-7.0	Most	20-40	80-250 (110 ave.)	+Prolific, viney growth +Most cold tolerant of available winter annual legumes
Field Peas	March-April OR late summer	Winter annual/ Summer annual[b]	7	3	5	4	6.5-7.5	Clay loam	70-220	172-190	+Rapid growth in chilly weather

NI=No Information, NFT=No Frost Tolerance. Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. [a] Nitrogen fixed but not total available nitrogen. See Section 8 for more information. [b] Winter killed. Reprinted with permission from Rodale Institute 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	Heat	Drought	Shade	pH Preference	Soil Type Preference	Seeding (Lb/A)	Comments
				--Tolerances--						
Brassicas e.g. mustards, rapeseed	April or late August-early Sept.	Annual / Biennial [b]	6-8	4	6	NI	5.3-6.8	Loam to clay	5-12	+Good dual purpose cover & forage +Establishes quickly in cool weather +Biofumigant properties
Buckwheat	Late spring-summer	Summer annual [b]	NFT	7-8	4	6	5.0-7.0	Most	35-134	+Rapid grower (warm season) +Good catch or smother crop +Good short-term soil improver for poor soils
Cereal Rye	August-early October	Winter annual	3	6	8	7	5.0-7.0	Sandy to clay loams	60-200	+Most cold-tolerant cover crop +Excellent allelopathic weed control +Good catch crop +Rapid germination & growth +Temporary N tie-up when turned under
Fine Fescues	Mid March-mid-May OR late Aug.-late Sept.	Long-lived perennial	4	3-5	7-9	7-8	5.3-7.5 (red) 5.0-6.0 (hard)	Most	16-100	+Very good low-maintenance permanent cover, especially in infertile, acid, droughty &/or shady sites
Oats	Mid-Sept-early October	Summer annual[b]	8	4	4	4	5.0-6.5	Silt & clay loams	110	+Rapid growth +Ideal quick cover and nurse crop
Ryegrasses	August-early Sept.	Winter annual (AR)/ Short-lived perennial (PR)	6 (AR) 4 (PR)	4	3	7 (AR) 5 (PR)	6.0-7.0	Most	14-35	+Temporary N tie-up when turned under +Rapid growth +Good catch crop +Heavy N & moisture users
Sorghum-Sudangrass	Late spring-summer	Summer Annual [b]	NFT	9	8	NI	Near neutral	NI	10-36	+Tremendous biomass producers in hot weather +Good catch or smother crop +Biofumigant properties

NI-No Information, NFT-No Frost Tolerance. AR=Annual Rye, PR=Perennial Rye.
Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. [b]Winter killed. Reprinted with permission from Rodale Institute www.rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook. (Reference 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. These buffers commonly range between 20 to 250 feet depending on adjacent field practices.

4.2 Crop Rotation Plan

A careful crop rotation plan is the cornerstone of organic crop production because it allows the grower to improve soil quality and proactively manage pests. Although growing a wide range of crops complicates the crop rotation planning process, it ensures diversity in crop residues in the soil, and a greater variety of beneficial soil organisms. Individual organic farms vary widely in the crops grown and their ultimate goals, but some general rules apply to all organic farms regarding crop rotation. Rotating individual fields away from crops within the same family is critical and can help minimize crop-specific disease and non-mobile insect pests that persist in the soil or overwinter in the field or field borders. Pests that are persistent in the soil, have a wide host range, or are wind-borne, will be difficult to control through crop rotation. Conversely, the more host specific, non-mobile, and short-lived a pest is, the greater the ability to control it through crop rotation. The amount of time required for a crop rotation is based on the particular pest and its severity. Some particularly difficult pests may require a period of fallow. See specific recommendations in the disease and insect sections of this guide (Sections 11, 12, 13). Partitioning the farm into management units will help to organize crop rotations and ensure that all parts of the farm have sufficient breaks from each type of crop.

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

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

Rotating crops that produce abundant organic matter, such as hay crop and grain-legume cover crops, with ones that produce less, such as vegetables, will help to sustain organic matter levels and promote good soil tilth (see Section 2: *Soil Health* and Section 8: *Crop and Soil Nutrient Management*). Spinach generally has a medium nutrient requirement (Table 4.2.1). Growing a cover crop, preferably one that includes a legume (unless the field has a history of *Pythium* or *Rhizoctonia* problems), prior to or after a spinach crop, will help to renew soil nutrients, 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 Crops Nutrient Requirements

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

From NRAES publication *Crop Rotation on Organic Farms: A Planning Manual.* Charles L. Mohler and Sue Ellen Johnson, editors, (Reference 24).

Crop Information Specific to Spinach

Cover Crops: Grow winter-killed cover crops such as oats and peas before spinach to simplify seedbed preparation. Spinach can also be fall planted after a fall incorporated cover crop, such as buckwheat or sorghum-sudangrass, and overwintered for an early spring harvest (See Section 5: *Weed Management* and Section 7: *Planting*).

Downy Mildew: Spinach, beets and Swiss chard are in the same plant family and all host downy mildew. Ideally, plant these crops only once every three to four years in the same field. See Cornell's information on the minimum rotation time required to avoid specific diseases (Reference 25).

White rust: Spinach is the only known crop host to white rust, which has structures that can survive in the soil and on infected crop debris for one year or more.

Pythium and Rhizoctonia: Both *Pythium* and *Rhizoctonia* are good at colonizing on incorporated crop debris and green manures, especially under wet soil conditions. High populations of *Pythium* and *Rhizoctonia* will affect emergence and stand establishment. Plan several weeks between incorporating green manure and planting spinach to allow for decomposition and for equilibrium to be established among soil organisms.

See Table 4.2.2 for more crop rotation information specific for spinach. For more details, see Crop Rotation on Organic Farms: A Planning Manual edited by Charles L. Mohler and Sue Ellen Johnson (Reference 24).

Table 4.2.2 Potential Interactions of Crops Grown in Rotation with Spinach

Crops in Rotation	Potential Rotation Effects	Comments
overwintered spinach beets Swiss chard	**downy mildew** *increase*	To avoid build up of downy mildew, do not plant in or near fields where spinach or plants in the Chenopodiaceae family have been grown for at least 2 years.
onion leek carrot	**weed** populations *reduced*	A short season crop like spinach can break weed cycles by not providing time for weeds to produce seeds. Plant spinach prior to slow growing, long season, weed prone crops like onion and carrot.
lettuce cucurbits radish peas	maximize resources	Plant lettuce, radish or cucurbit as a double crop after spinach or plant peas before spinach to take full advantage of the growing season.
alfalfa clover	**Pythium** and **Rhizoctonia** *increase*	Legume cover crops are good hosts to Pythium and Rhizoctonia. Do not plant spinach after a legume cover crop in a field with a known history of damage by these pathogens.
grain crops	**Pythium** and **Rhizoctonia** *decrease*	Grain crops are the best choice as cover or rotational crops before planting spinach since they generally are not alternate hosts for spinach pests.

Excerpt from Appendix 2 of Crop Rotation on Organic Farms: A Planning Manual. Charles L. Mohler and Sue Ellen Johnson, editors. (Reference 24)

4.3 Pest History

Knowledge about the pest history of each field is important for planning a successful cropping strategy. Germination may be reduced in fields with a history of *Pythium* or *Rhizoctonia*. Avoid fields that contain heavy infestations of perennial weeds such as nutsedge, bindweed, and quackgrass as these weeds are particularly difficult to control. One or more years focusing on weed population reduction using cultivated fallow and cover cropping may be needed before organic crops can be successfully grown in heavily weed infested fields.

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, result in leaves staying wet. 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.

Since spinach is a direct seeded crop that cannot be easily weeded within the row, reducing the weed seed bank is an important component of organic weed management. Try to plant spinach in fields with a recent history of good weed control.

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 27-28).

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 spinach in fields that have been free from alternate hosts such as common lambsquarters.

For both spring and summer plantings, till early enough in the spring to prevent winter annual weeds like chickweed and shepherd's purse from going to seed. For fall-harvested spinach, precede planting with a cultivated fallow period to reduce the weed seed bank. If chickweed is a problem, do the fallow in the spring and grow lettuce or a buckwheat cover crop during mid-summer. For a cultivated fallow, prepare a firm seed bed. Harrow thoroughly but at a shallow depth 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. 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 small pieces of cover crop residue on the surface to intercept raindrops and create a spongy soil consistency that will absorb rain and avoid crusting.

Begin cultivating about 2 weeks after planting. For best results, use vegetable knives on a belly mounted cultivator to get close to the rows without burying the young spinach. 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 10 to 14 day intervals to avoid letting weeds grow larger than 2 inches. Usually two or three cultivations are sufficient. 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.

If the setup does not allow cultivation close enough to the row, a hand hoeing along the edge of the row may be needed. The optimal time for hand hoeing is generally just after the second cultivation. The broken soil surface created by the cultivator makes hoeing easier and more accurate. A well-sharpened stirrup hoe is the best tool for this job.

With spinach the objective of weed management is not just reduction in competition. Untangling grass leaves and chickweed from spinach can impede harvest operations. Cleaning weeds out of spinach is easier if the whole plant is harvested by cutting the top of the taproot rather than by harvesting leaves.

Clean up the field soon after harvest. Spinach can be an effective component in the overall weed control because it is generally harvested before most weeds have time to set seed. It can act as a "cleaning" crop, reducing the seed bank preceding crops in which weed management is more difficult. But to receive this benefit from the spinach, weeds that established in the crop must be destroyed soon after harvest before they go to seed.

Resources

Crop Rotation on Organic Farms: A Planning Manual, Appendix 4 (Reference 24)
Cornell Weed Ecology website (Reference 26)
Rutgers Weed Gallery (Reference 27)
Steel in the Field (Reference 28)
Principles of sustainable weed management for croplands (Reference 30)
New cultivation tools for mechanical control in vegetables (Reference 31)
Weed 'em and reap videos (Reference 32)
Flame weeding for vegetable crops (Reference 33)
Vegetable Farmers and their Weed-Control Machines (Reference 34)
Twelve steps toward ecological weed management (Reference 35)

6. Recommended Varieties

Variety selection is important both for the horticultural characteristics specified by the processor and the pest resistance profile that will be the foundation of a pest management program. If the field has a known pest history, Table 6.1.1 can help determine which varieties might be resistant or tolerant of the problem. Consider the market when choosing varieties, selecting those with some level of disease resistance if possible.

Spinach varieties are distinguished by leaf texture and range from flat (smooth) leaves to savoy (crinkled) leaves. Flat leaf types are easier to clean than the savoy types, often more tender, and commonly used for baby leaf production. Leaves of the savoy types are more substantial, requiring fewer leaves per bag or bunch, and have a slightly longer shelf life. Some of the most cold tolerant varieties are savoy types.

Depending on the time of planting, other characteristics are important to consider when choosing spinach varieties such as bolting tolerance, growth rate, disease resistance and growth habit. Plant slow-bolting varieties for late spring and summer harvest, and fast-growing varieties for fall, winter, and early spring harvest. Late season spinach (planted in August) may be at higher risk from spinach yellows or cucumber mosaic virus, so resistant varieties such as Melody are a good choice if possible. Plants with an upright growth habit maintain cleaner leaves, are easier to harvest and usually yield a more productive second cutting. See Table 6.1 for spinach varieties.

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 Spinach Variety Resistance and Cultural Characteristics

Variety	Cucumber mosaic virus	Downy mildew[1]	White rust	Bolt Tolerance	Heat	Tip burn	Days to Maturity	Leaf type[2]	Planting Season[3]	Comments
7-Green		1-7		M			36	F	S, Su, F	Hy, upright plant
Avon	X	1-2					44	S-s	S, F, F(OW)	Hy, upright plant
Baker		1-3								Hy
Bloomsdale Long Standing	X			X			40-48	S	S,F F(OW)	OP, good emergence in cold soil
Bloomsdale Savoy				M			50	S	S,F	OP
Bordeaux		X		early bolt			21 baby 32 mature	F		Hy, dk green, red veins
Coho[4]		1,2,3	X	H				S-s	S, F, F(OW)	
Correnta		1-3		X			45	F	S,Su	Hy
Crocodile RZ		1-7, 9		X				S-s	Su S, Su, F	Hy, baby leaf production- summer
Cypress		1,2,3					60	S-s	S	Hy, upright plants
Dynasty		1,3		early bolt			extra early	F		Hy
Double Choice			X					F		Hy, baby and mature harvest
Early Prolific			X							Hy
El Forte		1-10		X			33		S, Su, F	Hy, upright plants
El Grinta		1-10					30	S-s	S, F	Hy, baby and juvenile size, upright plants
Emilia		1-10		X			38	S-s	S,F	Hy
Emu		1-10		H			42	F	S, ESu, F	Hy, baby leaf
Erste Ernte				early bolt			30	F	S	OP upright plants early to bolt
Esmeralda		1-4		early	X					Hy
Fall Green[4]	H	1,2	M					S-s	F	
Harmony				X			42	S	S	Hy
Hector		1,2,3		X			37	F		Hy, upright plant
Lombardia		1-7		X			38	S-s	S, Su, F	Hy, baby leaf or full size
Marabu RZ	X	1-10		X				S-s	S, Su, F	Hy
Melody[4]	H	1,2		X			42-50	S-s	S, EF F, F(OW)	Hy, upright plant
Menorca	X	1-7		X			39-44	S	S, EF S, Su, F	Hy, baby leaf, teen, full size
Monza		1-10					40	S-s	F	baby through teen age

Table 6.1 Spinach Variety Resistance and Cultural Characteristics

Variety	Cucumber mosaic virus	Downy mildew[1]	White rust	Bolt Tolerance	Heat	Tip burn	Days to Maturity	Leaf type[2]	Planting Season[3]	Comments
Olympia		1,2,3		best in flat leaf class			38-46	F	S, Su, EF, F(OW)	Hy, excellent for OW
Oriental Giant		1,2,3,4		X			14-21 baby 40 mature	F[2]	S, F	Hy, very fast growing
Polydane		1,2,3,4		X	X		50	F	S, Su, F	Hy, upright plants
Regal		1-7					30	S-s		Hy
Regiment		1-7		X			37	S	S, Su, F LS, F	Hy, upright plants; baby or full size
Renegade	H	1-7		X			42	slight-s	S, F, F(OW)	F1 Hy proven variety for winter high tunnels
Remington		X		X			38	S-s	S, Su, F	Hy
Salad Fresh				X			55			Hy, withstands harsh weather
Samish[4]		1,2,3,4	M				37-45	S-s	S, F, F(OW)	Hy, fall fresh market’ baby leaf
Santorini		1-7		X			45	S-s	S, Su, F	great for baby leaf
Sardinia		1-7					44	S-s	S, F	Hy, baby leaf, good bagged
Scarlet		1,2,3					44	F		Hy, baby leaf, red vein,
Space		1-3,5,8		X			39-50	S-s	S, Su, F	Hy, upright plant’ processors favor
Spargo		1-4		X			37-40	S-s	S, Su, F	Hy, upright plant
Spaulding				H			45	S-s	Su	Hy, upright plant
Spinner		1-5		X	X		38	S-s	S, Su, F	Hy upright plant
Spiros		1-4		X			36	S-s	S, F	Hy
Springer		X		X		X	37-40	S-s		Hy, upright plants
Tarpy F1		1-7					37	F	S,F	Hy, early spring prod under rowcover
Teton		1-4		X			48	F	LS, Su, EF	Hy
Toscane		1-7					37	S-s	S, Su, F	Hy, very fancy baby leaf
Tyee[4]	X	1-3		H	X		39-45	S-s	S, Su, EF, F(OW)	Hy, most bolt resistant savoy type; upright
Umbria		X		X						Hy
UniPack 12		1-4		X			48	F		Hy
UniPack 151[4]	M	1-4			X		48[2]	S-s	S, EF, F(OW)	Hy
Vancouver[4]		1-3	M					F		
Vienna[4]	H	1,2						S	F(OW)	
Whale		1-7		M		X	37	F	S, Su, F	Hy, excellent baby leaf and bunched
Winter Bloomsdale	X	X		X	X			S	S, Su, F(OW)	OP
Spinach-like plants										
Malabar “climbing spinach”					X		110			OP, vining *Basella alba*
New Zealand ‘spinach’					X		52-70			OP, withstands frost to low 20’s *Tetragonia tetragonioides*

(Adapted from Reference 56 Vegetable MD Online Spinach: Disease Resistance Table with additional information from seed companiesHy=hybrid, OP=Open pollinated. 1- Resistance against these races of downy mildew. Degree of resistance: H=high, M=medium, L=Low, X= some resistance but degree unknown. 2. S= savoy, S-s= semi-savoy, F= flat 3. S=spring, Su= summer, F= fall, F(OW)= fall planted to overwinter, E=early . 4. Recommended for New York farms.

7. Planting

Spinach is a cool-season vegetable that grows rapidly and with the highest quality at temperatures of 55° to 60°F with medium day lengths. The seed can germinate between 32° and 60°F and young plants withstand temperatures as low as 18° without damage. Table 7.0.1 includes the range of dates for planting spinach in New York. Usual frost dates and other local weather or soil conditions must be considered in determining planting dates in each area. Most growers start planting when the first favorable weather break occurs in or near the planting ranges indicated below.

Table 7.0.1 Planting and Harvest Dates

Planting Season	Planting Dates	Harvest dates	Suitable Varieties
Spring	March 15 - May 7	May 1 - July 1	Coho, Melody, Tyee, UniPack 151
Summer	May 15 - June 15	July 1 - August 1	7-green, Correnta, Crocodile RZ, El Forte, Lombardia, Marabu RZ, Menorca, Olympia, Polydane, Regiment, Remington, Santorini, Space, Spargo, Spaulding, Spinner, Teton, Toscane, Tyee, Whale, Winter Bloomsdale
Midsummer	August 1 - August 15	September 15 - Oct 15	Fall Green, Melody, Samish, Coho, UniPack 151
Fall/ Overwintered	September 1- 15	April 15 - May 15	Avon, Bloomsdale Long Standing, Coho, Melody, Olympia, Renegade, Samish, Tyee, Unipack 151, Vienna, Winter Bloomsdale

Spinach seeds require a finely manicured, firm, level seedbed. Incorporate the previous crop or cover crop and allow time for decomposition to prevent residues from hindering crop establishment. Prepare the seedbed by disking or rototilling followed by rolling. See more information in section 5: Weed Management.

Spinach for fresh market is generally planted in rows 12 to 18 inches apart, while spinach for processing is planted in narrower rows, ranging from 10 to 12 inches, depending on harvesting equipment. Somewhat thinner stands will help control foliar diseases by providing better air circulation. Sow seeds to the correct spacing because thinning is not recommended.

Table 7.0.2 Recommended Spacing

Type	Row[1] (inches)	In-row (plants/ft)	Seed Depth[2] (inches)
Fresh market, bunched or bagged	12-18	6-8	0.25-0.5
Baby leaf	3-5	6-12	0.25-0.5
Processing	10-12	10-15	0.25-0.5

1-For both fresh and processing markets, the most common arrangement is 4-5 rows on 68-72 inch beds. 2-Plant seed deeper in warm, dry soil.

Spring planting/ Summer Planting

Winter-killed cover crops such as oats and field peas leave an easy to manage residue on the soil surface that facilitates early planting. Seeding spinach can start as soon as the soil is tillable in the spring. In the cool regions of northern New York, seed in May and June for the summer market.

Mid-Summer Planting

Seed for the fall harvest in early August. Plant spinach after a lettuce, radish or pea crop, or incorporate a cover crop such as buckwheat or millet. Allow at least 3 weeks for decomposition of any organic matter before planting. Alternatively, precede planting with a cultivated fallow period to reduce the weed seed bank (See Section 5.2: *Cultivation*).

Fall Planting for Overwintered Spinach

Spinach for an early spring harvest is routinely overwintered on Long Island with seeding dates around mid-September. In upstate New York, overwintering spinach is more of a gamble but can be successful if the winter is mild. Fill any niches between early spring and fall spinach plantings with a quick-growing cover crop like buckwheat or millet. Plan 2-3 weeks between green manure incorporation and spinach planting to allow for decomposition and for equilibrium to be established among soil organisms. Over wintered plantings in upstate New York are seeded in early September. Plants should have 4-5 true leaves before growth stops for the winter. Mulch plants heavily with straw and remove before growth begins again in the spring. Some farmers have experimented with planting oats between rows of overwintered spinach to grow mulch in place for use in the winter.

Overwintered spinach will escape most leafminer damage if harvested prior to mid-May. Early harvest of overwintered or early spring planted spinach can also avoid damage from green peach aphids, whose populations peak later in May. Avoiding aphids also reduces the likelihood of infection from the cucumber mosaic virus that they transmit. Likewise cabbage loopers are generally not a problem until late summer.

Transplanting

Spinach transplants might be economical on very small acreages, or planted on plastic, although it is not common. Start transplants 5 to 6 weeks before the last frost-free date. Plants should have 4 to 6 mature leaves at transplanting.

8. Crop and Soil Nutrient Management

To produce a healthy crop, soluble nutrients must be available from the soil in amounts that 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. 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. Restrictions in any one of the needed nutrients will slow growth and can reduce crop quality and yields.

Organic growers often speak of feeding the soil rather than feeding the plant. A more accurate statement is that organic growers focus their fertility program on feeding soil microorganisms rather than the plant. 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 and are 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, amending soils with composts or composted 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. A more sustainable, long-term approach is to rely more on legume cover crops to supply most of the nitrogen needed by the crop. 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.

The primary challenge in organic systems is synchronizing nutrient release from organic sources, particularly nitrogen, with the crop requirements. 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 - 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. Confirm the practice with your organic certifier prior to field application.

Regular soil testing helps monitor soil pH and nutrient levels, in particular phosphorus (P), potassium (K), and micronutrients. Choose a reputable soil-testing lab (Table 8.0.1) and use it consistently to avoid discrepancies caused by different soil nutrient extraction methods. Maintain a pH of 6.5 to 6.8 in upstate New York and 6.0 to 6.2 on Long Island. Spinach is particularly sensitive to soil acidity and may exhibit low germination, leaf tip yellowing or browning, root burn, and overall slowed growth if soil pH is too low. On soils with high pH, spinach leaves may become chlorotic. See Table 8.2.2 for the recommended rates of phosphorus and potassium based on soil test results. Soil tests are required prior to micronutrient application to certified organic soil. Check with your certifier that the micronutrient source is approved for use.

Table 8.0.1 Nutrient Testing Laboratories

Testing Laboratory	Soil	Compost/ Manure	References
Cornell Soil Health Lab	x		20
Agri Analysis Inc.		x	39
A & L Eastern Laboratories, Inc.	x	x	40
Penn State Agricultural Analytical Services Lab	x	x	41
Agro One Services	x	x	42
University of Massachusetts	x	x	43

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.*

8.1 Fertility

Recommendations from the Cornell Integrated Crop and Pest Management Guidelines indicate spinach requires 80-100 lbs. of available nitrogen (N), 140 lbs. of phosphorus (P), and 150 lbs. of potassium (K) per acre. These levels are based on the total nutrient needs of the whole plant and assume the use of synthetic fertilizers. Farmer and research experience suggests that lower levels may be adequate in organic systems. See Table 8.2.2 for the recommended rates of P and K based on soil test results. Nitrogen is not included because levels of available N change in response to soil temperature and moisture, N mineralization potential, and leaching. As many of the nutrients as possible should come from cover crop, manure, and compost additions in previous seasons.

The source of these nutrients depends on soil type and historic soil management. Some soils are naturally high in P and K, or have a history of manure applications that have resulted in elevated levels. Additional plant available nutrients are supplied by decomposed soil organic matter or through specific soluble nutrient amendments applied during the growing season in organically managed systems. Many types of organic fertilizers are available to supplement the nutrients supplied by the soil. ALWAYS check with your certifier before using any product to be sure it is approved.

Spinach has a limited root system, and is not efficient at pulling nutrients from the soil. If spinach is stressed by a lack of nutrients, vegetative growth is slowed and the plants are more prone to bolting. See Table 8.1.1 for common nutrient deficiency symptoms.

Nitrogen deficiency may be confused with magnesium deficiency in spinach, because the symptoms can be similar. If older leaves are yellow or the plant has a general pale green color, check soil for magnesium deficiency before applying additional nitrogen. Excess nitrogen can cause nitrates to build up in the plants. Correct low soil magnesium levels by adding high magnesium lime (dolomitic) to the soil, adding magnesium to the fertilizer, or by making a foliar application of 10-15 lbs. magnesium sulfate (Epsom salts) in 100 gallons of water. Spinach responds quickly to foliar applications when magnesium is lacking.

Table 8.1.1 Nutrient Deficiency Symptoms

Nutrient Deficiency	Symptoms
nitrogen	older leaves yellow; pale green color overall; stunted stems
magnesium	older leaves yellow with dark green veins; pale green color overall
phosphorous	slowed growth; bluish green older leaves
potassium	browning at leaf tips

8.2 Preparing an Organic Nutrient Budget

Insuring an adequate supply of nutrients when the crop needs them requires careful planning. Developing an organic nitrogen budget can help estimate the amount of nutrients released by various organic amendments as well as native soil organic matter. 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.

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. Consider submitting soil samples for a Cornell Soil Health Test (Reference 20). This test includes an estimate of nitrogen mineralization rate, which indicates the potential for release of N from soil organic matter. Testing soils over time can be useful for monitoring changes in nitrogen mineralization rate during the transition, and over time, in organic production.

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 8.2.1 Calculating Nutrient Credits and Needs.

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

Line 1. Total Crop Nutrient Needs: Research indicates that an average spinach crop requires 80-100 lbs. of available nitrogen (N), 140 lbs. of phosphorus (P), and 150 lbs. of potassium (K) per acre to support a medium to high yield (see section 8.1: *Fertility* above). More nitrogen may be required for a processing crop than a fresh market crop.

Line 2. Recommendations: 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 P and K for Spinach Based on Soil Tests

	N Level	Soil P Level			Soil K Level		
Level shown in soil test	Not available	low	med	high	low	med	high
	N lbs/A	**P_2O_5 lbs/A**			**K_2O lbs/A**		
Total nutrient recommendation	80-100	140	110	80	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 spinach is eaten fresh, the use of manure as a nutrient supplement is generally not recommended unless it has been composted according to the National Organic Program (NOP) guidelines. The NOP rules allow manure applications 120 days or more before harvest, but your farm certifier may have a more restrictive policy. Regulations resulting from the Food Safety Modernization Act (FSMA) will supercede NOP rules. Be aware of how FSMA regulations apply to your farm

Line 3c. Compost: Estimate that between 10 and 25% of the N contained in most compost is available to the crop the first year. Compost maturity will influence how much N is available. If the material is immature, more of the N may be available to the crop in the first year. A word of caution: Using compost to provide for a crop's nutrient needs is not generally a financially viable strategy. The high total volume needed, can be very expensive for the units of N available to the crop, especially if trucking is required. Most stable composts should be considered as soil conditioners, improving soil health, microbial diversity, tilth, and nutrient retaining capacity. Any compost applied on organic farms must be approved for use by your farm certifier. Compost generated on the farm must follow an approved process outlined by your certifier.

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

Line 4. Total Credits: Add together the various N values from soil organic matter, compost, and cover crops to estimate the total N 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 sidedress application of organic N may be needed. There are several sources for N for organic sidedressing (see Table 8.2.4) as well as pelleted composts. If early in the organic transition, a grower may consider increasing the N budget supply by 30%, to help reduce some of the risk of N being limiting to the crop.

Table 8.2.3 includes general estimates of nutrient availability for manures and composts but these can vary widely depending on animal feed, management of grazing, the age of the manure, amount and type of bedding, and many other factors. See Table 3.1 for estimates of the nitrogen content of various cover crops. **Manure applications may not be allowed by your certifier or marketer even if applied 120 days before harvest. Check with both these sources prior to making manure applications.**

Table 8.2.3 Nutrient Content of Common Animal Manures and Manure Composts

	TOTAL N	P_2O_5	K_2O	N1 [1]	N2 [2]	P_2O_5	K_2O
	NUTRIENT CONTENT LB/TON			*AVAILABLE NUTRIENTS LB/TON IN FIRST SEASON*			
Dairy (with bedding)	9	4	10	6	2	3	9
Horse (with bedding)	14	4	14	6	3	3	13
Poultry (with litter)	56	45	34	45	16	36	31
Composted dairy manure	12	12	26	3	2	10	23
Composted poultry manure	17	39	23	6	5	31	21
Pelleted poultry manure [3]	80	104	48	40	40	83	43
Swine (no bedding)	10	9	8	8	3	7	7
	NUTRIENT CONTENT LB/1000 GAL.			*AVAILABLE NUTRIENTS LB/1000 GAL FIRST SEASON*			
Swine finishing (liquid)	50	55	25	25[4]	20+	44	23
Dairy (liquid)	28	13	25	14[4]	11+	10	23

1-N1 is an estimate of the total N available for plant uptake when manure is incorporated within 12 hours of application, 2-N2 is an estimate of the total N available for plant uptake when manure is incorporated after 7 days. 3 –Pelletized poultry manure compost. (Available in New York from Kreher's.) 4- injected, + incorporated. Adapted from *"Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops"* by Carl Rosen and Peter Bierman (Reference 45) and Penn State Agronomy Guide 2007-8 (Reference 46).

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 44).

Table 8.2.5 Available Phosphorous in Organic Fertilizer

	Pounds of Fertilizer/Acre to Provide X Pounds of P_2O_5 Per Acre				
Sources	20	40	60	80	100
Bonemeal 15% P_2O_5	130	270	400	530	670
Rock Phosphate 30% total P_2O_5 (x4)[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 44).

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 44).

An example of how to determine nutrient needs for spinach:

You will be growing an acre of spinach for fresh market. The *Cornell Integrated Crop and Pest Management Guidelines* suggests a total need of 100 lb. N, 140 lb. P, and 150 lb. K per acre to grow a high yielding crop. Soil test results show a pH of 6.0, with high P and medium K levels and recommend 80 lbs P_20_5/acre and 100 lbs K_20/acre (see Table 8.2.2). The field has 2% organic matter. Last fall 3 tons/acre of composted dairy manure was spread and immediately incorporated prior to planting a cover crop of oats. Nutrient credits for soil organic matter, manure, and cover crop appear in Table 8.2.7.

Table 8.2.7 Spinach 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:	100	140	150
2. Recommendations based on soil test	# not provided	80	100
3. Credits			
a. Soil organic matter 2%	40	---	---
b. Manure			
c. Composted dairy manure 3T/A	9	30	69
d. Cover crop – oat	-		
4. Total credits:	49	30	69
5. Additional needed (2-4) =	51	50	31

Table 8.2.3 indicates about 9 lbs N will be released in the first season from the 3 tons/acres of composted dairy manure (N1). Estimate that each percent organic matter will release about 20 lbs of N, so the 2% organic matter will supply 40 lbs (line 3a). While a small amount of nitrogen will be released from the killed oat residue, it is difficult to accurately quantify how much. The total estimated N released and available for plant uptake is 49 lbs per acre (line 4). Line 5 suggests that 51 lbs of additional N is needed which can be added by side-dressing 1275 lbs/acre of soy meal. P and K will also need to be supplemented. Looking at P, the compost supplies 30 of the 80 lbs/acre recommended by the soil test. Apply 338 lbs/acre of bonemeal to meet the 50 lbs/acre deficit. The compost also supplies ~70 lbs of the 100 lbs needed potassium. The remaining 30 lbs K2O/acre can be added by applying ~135 lbs. of Sul-Po-Mag, broadcast and then incorporated.

9. HARVESTING

Most varieties reach fresh market harvest stage in 40 to 50 days under good growing conditions, but 50 to 70 days may be required for early spring plantings. Spinach for the processing market can take longer to reach optimum size and texture.

Harvest during the coolest time of day and when leaves are dry. Insects and weeds are considered contaminants at harvest. Handle carefully as spinach is vulnerable to bruising.

9.1 Harvest Methods

Spinach for all markets except baby leaf can be harvested beginning when plants have five or six leaves; for higher yields, delay harvest until plants have 10 to 12 leaves

Harvest spinach for baby leaf markets by cutting just above the soil line with shears, a knife or a harvester, when leaves are young and tender. Cut spinach for the bagged market just above the plant crown. In either case, spinach will regrow and be ready for harvest again in 10-14 days, although yield and quality of the second cutting is much lower than the first. Spinach for the bagged market is usually harvested into large pallets, then washed, bagged and hydro-cooled.

Spinach sold in bunches is harvested by cutting the whole plant just below the soil line. Plants are then loosely packed into crates or cartons or bunched in the field.

Processing spinach is usually mechanically harvested. Leaves are mowed 6-7 inches above the ground in order to avoid stem, petioles and older or yellow leaves. The second cutting is generally made 3-4 weeks after the first, and as with fresh market spinach, the second harvest is lower in yield and quality.

9.2 Storage

Spinach is a very perishable product, but if picked early in the day, cooled rapidly after harvest, and topped with ice it can be stored for 10 to 14 days. Cooling will reduce the naturally high respiration rate of spinach. Forced air or vacuum cooling provides a quick reduction in temperature. The use of top ice acts to supply moisture and remove heat. Always use ice made from potable water. Air flow through and around boxes is also essential.

Optimal storage conditions are 32°F with 95 to 100 percent relative humidity. Spinach leaves will yellow if transported with high ethylene producing crops such as apples, melons or tomatoes.

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 spinach, but check with your certifier or marketer for separate restrictions for manure use on spinach. 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.

Table 9.3.1 Rates for Disinfectants Labeled for Postharvest Spinach 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				
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 gallons of water [3]
Pro oxine[2]	50-200 ppm solution	500 ppm solution		
hydrogen peroxide/peroxyacetic acid				
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			
*SaniDate 5.0	1.6 fl oz/ 5 gal water	1.6 fl oz/ 5 gal water		
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 Liquid Sanitizer and Disinfectant OAI	1-1.7 fl oz/5 gal water	1-11 fl oz/16 gal water		
VigorOx 15 F & V	0.31-0.45 fl oz/5 gal water	1.1-9.5 fl oz/5 gal water	Unprocessed spinach: 1 fl oz/ 16 gal water as spray or dip Processed spinach: 1.5 fl oz/25 gal water as spray or dip	0.54 fl oz/ 16 gal water
VigorOx LS-15	0.31-0.45 fl oz/5 gal water	1.1-9.5 fl oz/5 gal water		
sodium hypochlorite				
San-I-King No. 451	100 ppm chlorine in solution			
* Restricted-use pesticide in New York State.				

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

Resources

New England vegetable management guide: spinach (Reference 4)
Vegetable crop production guide for Nova Scotia: spinach (Reference 5)
United States standards for grades of bunched spinach (Reference 47)
United States standards for grades of spinach leaves: fresh (Reference 48)
United States standards for grades of spinach for processing (Reference 49)

10. Using Organic Pesticides

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

10.1 Sprayer Calibration and Application

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

Resources

Cornell Integrated Crop and Pest Management Guidelines: Pesticide Information and Safety (Reference 51).
Calibrating Backpack Sprayers (Reference 52).
Agricultural Pocket Pesticide Calibration Guide (Reference 53).
Knapsack Sprayers – General Guidelines for Use (Reference 54)

10.2 Regulatory Considerations

Organic production focuses on cultural, biological, and mechanical techniques to manage pests on the farm, but in some cases organically approved pesticides, which include repellents, are a necessary option. Pesticides mentioned in this organic production guide must be registered and labeled at the federal level for use, like any other pesticide, by the Environmental Protection Agency (EPA), or meet the EPA requirements for a "minimum risk" pesticide, making it exempt from normal registration requirements as described in FIFRA regulation 40 CFR Part 152.25(b) (Reference 18).

"Minimum risk" pesticides, also referred to as 25(b) pesticides, must meet specific criteria to achieve the "minimum risk" designation. The active ingredients of a minimum-risk pesticide must be on the list of exempted active ingredients found in the federal regulations (40 CFR 152.25). Minimum-risk pesticides must also contain inert ingredients listed on the most current List 4A published in the Federal Register (Reference 18a).

In addition to meeting the active and inert ingredient requirements above, a minimum-risk pesticide must also meet the following:

- Each product must bear a label identifying the name and percentage (by weight) of each active ingredient and the name of each inert ingredient.
- The product must not bear claims to either control or mitigate microorganisms that pose a threat to human health, including, but not limited to, disease-transmitting bacteria or viruses, or claim to control insects or rodents carrying specific diseases, including, but not limited to, ticks that carry Lyme disease.
- The product must not include any false or misleading labeling statements.

Besides registration with the EPA, pesticides sold and/or used in New York State must also be registered with the New York State Department of Environmental Conservation (NYS DEC). However, pesticides meeting the EPA "minimum risk" criteria described above do not require registration with the NYS DEC.

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 15). The Organic Materials Review Institute (OMRI) (Reference 9) is one organization that reviews and publishes products they find compliant with the NOP regulations, 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 potential pesticides.

Finally, each farm must be certified by an accredited certifier who must approve any material applied for pest management. ALWAYS check with the certifier before applying any pest control products.

Some organic certifiers may allow "home remedies" to be used to manage pests. These materials are not labeled as pesticides, but may have properties that reduce the impact of pests on production. 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. Home remedies are not mentioned in these guides, but in some cases, may be allowed by organic certifying agencies. Maintaining good communication with your certifying agent cannot be overemphasized in order to operate within the organic rules.

10.3 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. Pesticide manufacturers are not required to demonstrate efficacy to list a pest on the label. The Resource Guide for Organic Insect and Disease

Management (Reference 3) 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. Read the pesticide label carefully to determine if water pH or hardness will negatively impact the pesticide's effectiveness. Use of a surfactant may improve organic pesticide performance. OMRI lists adjuvants on their website under *Crop Management Tools and Production Aids* (Reference 10). 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. Thoroughly cover plant surfaces, especially in the case of insecticides, since many must be ingested to be effective. 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.

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 and 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 *Rhizoctonia*, or pathogens that do not overwinter in New York, such as downy mildew. Rotation with a grain crop, preferably a sod 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. See more on crop rotation in Section 4.2: *Crop Rotation Plan.*

Other important cultural practices can be found under each individual disease listed below. Maximizing air movement and leaf drying is a common theme. Many plant diseases are favored by long periods of leaf wetness. Any practice that promotes faster leaf drying, such as orienting rows with the prevailing wind, using a wider row or plant 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 evaluating control measures. The earlier a disease is detected, the more likely it can be suppressed with organic fungicides. When available, scouting protocols can be found in the sections listed below for each individual disease. While following a systematic scouting plan, keep watch for other disease problems. Removing infected plants during scouting is possible on a small operation. Accurate identification of disease problems, especially recognizing whether they are caused by a bacterium or fungus, is essential for choosing an effective control strategy. Anticipate which diseases are likely to be problems that could affect yield and be ready to take control action as soon as symptoms are seen. Allowing pathogen populations to build can quickly lead to a situation where there are few or no options for control.

All currently available fungicides allowed for organic production are protectants meaning they must be present on the plant surface before disease inoculum arrives to effectively prevent infection. They have no activity on pathogens once they are inside the plant. A few fungicides induce plant resistance and must be applied several days in advance of infection to be effective. Biological products must be handled carefully to keep the microbes alive. Follow label instructions carefully to achieve the best results.

Contact your local cooperative extension office to see if newsletters and pest management updates are available for your region. For example, the Cornell Cooperative Extension Regional Vegetable Program in Western New York offers subscriptions to *Pestminder*, a report that gives timely information regarding crop development, pest activity and control, and *VegEdge*, a monthly newsletter with articles on pest management. On Long Island, see the *Long Island Fruit and Vegetable Update*.

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

Table 11.0 Pesticides Labeled for Disease Control in Organic Spinach

CLASS OF COMPOUND Product name *(Active ingredient)*	Anthracnose	Damping Off	Downy Mildew	Leaf Spot	White Rust
BIOLOGICAL					
Actinovate AG *(Streptomyces lydicus WYEC 108)*	X	X	X		
Actino-Iron (*Streptomyces lydicus WYEC 108)*		X			
BIO-TAM *(Trichoderma asperellum, Trichoderma gamsii)*		X			
Double Nickel 55 Biofungicide (*Bacillus amyloliquefaciens str. D747*)		X	X	X	
Double Nickel LC Biofungicide (*Bacillus amyloliquefaciens str. D747*)		X	X	X	
MycoStop Biofungicide *(Streptomyces griseoviridis)*		X			
MycoStop Mix (*Streptomyces griseoviridis*)		X			
Prestop Biofungicide *(Gliocladium catenulatum str. J1446)*		X			
Regalia Biofungicide Concentrate (*Reynoutria sachalinensis*)			X	X	X
RootShield WP (*Trichoderma harzianum*)		X			
RootShield PLUS+ WP *(Trichoderma harzianum str. T-22, Trichoderma virens str. G-41)*		X			
RootShield Granules (*Trichoderma harzianum*)		X			
RootShield PLUS+ Granules *(Trichoderma harzianum str. T-22, Trichoderma virens str. G-41)*		X			
Serenade ASO (*Bacillus subtilis*)			X		X
Serenade MAX (*Bacillus subtilis*)			X		X
Serenade Soil *(Bacillus subtilis)*		X			
SoilGard (*Gliocladium virens strain GL-21*)		X			
Taegro Biofungicide (*Bacillus subtilis var. amyloliquefaciens strain FZB24*)		X			
BOTANICAL					
Sporatec (*rosemary, clove and thyme oils*)			X		X
Trilogy (*neem oil)*	X		X	X	X
COPPER					
Badge *(copper oxychloride, copper hydroxide)*	X		X	X	X
Basic Copper 53 *(basic copper sulfate)*	X		X	X	X
Camelot O *(copper octanoate)*			X	X	X
Champ WG *(copper hydroxide)*	X		X	X	X
Cueva Fungicide Concentrate (*copper octanoate*)			X	X	X
CS 2005 *(copper sulfate pentahydrate)*	X		X	X	X
Nordox 75 WG (*cuprous hydroxide*)	X		X	X	X
Nu-Cop 50DF *(copper hydroxide)*	X			X	X
Nu-Cop 50 WP *(copper hydroxide)*	X		X	X	X
Nu-Cop HB *(cupric hydroxide)*	X		X	X	X
OTHER					
EcoMate ARMICARB 0 *(potassium bicarbonate)*	X		X		
Micro Sulf *(sulfur)*					X
Milstop (*potassium bicarbonate)*	X		X	X	
OxiDate Broad Spectrum*(hydrogen dioxide)*			X		X
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*			X		X
PERpose Plus (*hydrogen peroxide/dioxide*)	X	X	X	X	X

At the time this guide was produced, these materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System http://pims.psur.cornell.edu/ (Ref. 2). **ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.**

11.1 Damping-off and Seed Rot, *Pythium spp. and Rhizoctonia solani*

Time for concern: At seeding and in post emergence stage.

Key characteristics: These soilborne pathogenic fungi are present in most soils, but are often kept in balance by other beneficial fungi in well-managed, biologically active soils. They primarily cause a pre-emergence rot of seeds and seedlings, but if soils are very moist, then post-emergence rot of roots, stems and leaves can occur. See University of Connecticut photo (Reference 58).

Relative risk: Important and damaging pathogens, especially when debris from previous crop is not adequately decomposed before planting spinach. Using fresh seed may help.

Management Option	Recommendation for Damping-off and Seed Rot
Site selection	Deep plowing will speed decomposition of infected plant debris. Do not plant spring crop near over-wintered fields. Fungus may occur as a surface contaminant of the seed.
Crop rotation	A three-year crop rotation will reduce pathogen inoculum. Grain crops are the best choice as cover or rotational crops before planting spinach. Both Pythium and Rhizoctonia are good saprophytes and good competitors in colonizing and building-up on incorporated crop debris, especially under wet soil conditions. Allow 3 weeks at minimum between incorporating crop debris and planting to allow for decomposition and equilibrium to be established among soil organisms.
Resistant varieties	No resistant varieties are available.
Seed selection	Because fresh seed is generally more vigorous than older seed, young plants from fresh seed may grow through the highly susceptible stage of damping off more quickly.
Planting	Actively decomposing organic matter from crop debris or unfinished compost may affect emergence and stand establishment. Allow at least 3 weeks between previous crop/unfinished compost incorporation and planting. Practices that slow seedling growth such as planting seeds to deep, or planting in cold soils, can extend the period of time seedlings are likely to be infected by the pathogens that cause damping-off.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production
Cover crops	Legume cover crops (clovers, alfalfa) are good hosts to these pathogens, thus spinach planting should not follow these cover crops in fields with a history of these diseases. Plan 3 weeks at minimum between green manure incorporation and planting to allow for decomposition and equilibrium to be established among soil organisms. Use winter-killed cover crops such as oats, field peas, or brassicas to allow time for more complete decomposition.
Cultural controls	Plant rows in an east-west direction to maximize airflow around plants. Use raised beds to improve soil water drainage.
Biological controls	Biological seed treatments may improve stand establishment.

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref. 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 11.1 Pesticides Labeled for Management of Damping-off and Seed Rot					
CLASS OF COMPOUND **Product** ***(Active ingredient)***	**Rate**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
BIOLOGICAL					
***Bacillus spp*.**					
Double Nickel 55 Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.125-1 lb/A as soil spray or drench	0	4	?	
Double Nickel LC Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.5-4.5 pints/A as soil spray or drench	0	4	?	
Serenade Soil *(Bacillus subtilis)*	2-6 qt/A	0	4	?	Soil drench application.
Taegro Biofungicide (*Bacillus subtilis var. amyloliquefaciens strain FZB24*)	2.6 oz/100 gals/A 3 tsp/gal water 2.6 oz/100 gals for 2 acres	-	24	?	Labeled for Rhizoctonia only. As a drench. As seed treatment. Apply on row crops over furrow at time of planting.
Gliocladium					
Prestop Biofungicide *(Gliocladium catenulatum str. J1446)*	3.5 oz/100 sq ft	-	0	?	Soil drench application. Appply only to growth substrate when above-ground harvestable food commodities are available.
SoilGard (*Gliocladium virens strain GL-21*)	0.5 - 2 lbs/100 gallons/A 2-10 lbs/A 2-10 lbs/A	-	0	?	Before transplanting and at transplanting. Apply after transplanting. Applied as a banded drench in-furrow at or immediately before planting.
Streptomyces					
Actinovate AG (*Streptomyces lydicus WYEC 108*)	2-18 oz/acre of seed (seed treatment) 3-12 oz/A (soil treatment)	0	1 or until solution has dried	?	Apply as seed treatment or as a soil treatment at planting. For soil treatments, apply in 10-200 gallons of water per acre.
Actino-Iron (*Streptomyces lydicus WYEC 108*)	10-15 lbs/A	-	4	?	Apply in furrow at seeding or to established crops as a side-dress.
Mycostop Mix *(Streptomyces griseoviridis* Str. K61)	.05-.08 oz/pound of seed as seed treatment 7.6-30 oz/A as soil spray or drench 0.5-1 lb/ treated	-	4	?	Greenhouse use only for listed pathogens. Use at planting; no pre-harvest interval noted. Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop into the root zone. Lightly incorporate furrow or band

Table 11.1 Pesticides Labeled for Management of Damping-off and Seed Rot					
CLASS OF COMPOUND **Product** ***(Active ingredient)***	**Rate**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
BIOLOGICAL					
	acre as band, in-furrow or side dress.				applications.
Mycostop Biofungicide *(Streptomyces griseoviridis* Str. K61)	0.07 oz/pound of seed as seed treatment 15-30 oz/A as soil spray or drench	-	4	?	Greenhouse use only for listed causal organisms. Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop Biofungicide into the root zone.
Trichoderma spp.					*Trichoderma harzianum* products effective in 1/1 trial
BIO-TAM *(Trichoderma asperellum, Trichoderma gamsii)*	1.5-3 oz/1000 row ft, in-furrow 2.5-3 lb/A, banded	-	1	?	
RootShield WP (*Trichoderma harzianum str. T-22 (KRL-AG2)*)	3-5 oz/100 gal (greenhouse drench) 16-32 oz/A (in furrow/transplant starter solution)	-	0 (drench application); Until dry (field application)	1	
RootShield PLUS+ WP *(Trichoderma harzianum str. T-22, Trichoderma virens str. G-41)*	0.25-5 lb/20 gal water(cutting/ transplant dip) 16-32 oz/A, in-furrow	0	4	1	Do not apply when above-ground harvestable food commodities are present.
RootShield Granules (*Trichoderma harzianum str. T-22 (KRL-AG2)*)	5-12 lbs/A	-	0	1	In furrow application
RootShield PLUS+ Granules *(Trichoderma harzianum str. T-22, Trichoderma virens str. G-41)*	2.5-6 lb/half acre	-	0	1	In-furrow application
OTHER					
PERpose Plus (*hydrogen peroxide/ dioxide*)	1 fl oz/gal (initial/curative) 0.25-0.33 fl oz/gal (weekly/preventative)	-	1 (interior); until dry (field)	?	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.

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

11.2 Downy Mildew (Blue Mold), *Peronospora farinose* f. sp. *spinaciae*

Time for concern: Season long, especially if over-wintered inoculum is present. Most troublesome in cool, wet weather (60-68°) but can develop over a wide temperature range (36 to 77° F).

Key characteristics: This fungus causes systemic infection of spinach plants; 10 races are currently known. Symptoms appear first as blotchy yellow areas on upper leaf surfaces of older leaves, with corresponding grayish-purple downy mold on lower leaf surfaces. Symptoms move from older to younger leaves. Spores are spread by wind and splashing rain and can only germinate on moist leaf surfaces. The time of infection to production of new spores varies from 5-18 days depending on environmental conditions. The fungus can overwinter on seed and overwintered spinach plantings; it is unknown whether blue mold overwinters on soil and crop residue in NY as it does in more southern areas. In severe attacks, all plants in a field may be destroyed within a few days (Reference 57). See Penn State photo (Reference 57), Oregon State photo (Reference 59) and References 5 and 8.

Relative Risk: This is a very important spinach disease because it creates spots that make the spinach unmarketable and because it can spread rapidly resulting in significant yield loss. New races of this disease appear regularly and therefore incidence and behavior of this pathogen are not predictable.

Management Option	Recommendation for Downy Mildew
Site selection	Avoid fields with poor airflow and water drainage and soils with a history of downy mildew. Do not plant adjacent to fields where winter spinach was grown.
Crop rotation	Minimum two-year rotation without spinach.
Resistant varieties	Plant varieties with resistance to as many races as possible (see Section 6: *Varieties*).
Seed selection/ Treatment	This fungus can be seed-borne. Use seed stock that has been tested for this pathogen and found to be clean. Reducing initial inoculum is important, especially with a disease that is difficult to control once established. If seed contamination is suspected, treat seed in 122°F water for 25 minutes.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production.
Sanitation	Control Chenopodium weed hosts such as common lambsquarter. Soil inoculum levels can be reduced by deep plowing infected plant residue.

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref. 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 11.2 Pesticides Labeled for Management of Downy Mildew

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Actinovate AG (*Streptomyces lydicus*	3-12 oz	0	1 or until solution has	?	Apply in 10-150 gallons of water per acre. The label recommends using a

Table 11.2 Pesticides Labeled for Management of Downy Mildew					
CLASS OF COMPOUND **Product name** ***(Active ingredient)***	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
WYEC 108)			dried		spreader sticker for foliar applications.
Double Nickel 55 Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.25-3 lbs foliar spray	0	4	?	Repeat every 7-10 days or as needed.
Double Nickel LC Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.5-6 qts as foliar spray	0	4	?	
Regalia Biofungicide (*Reynoutria sachalinensis)*	0.5 – 4 qts /A	0	4	?	Apply using 50-100 gallons of water per acre. Repeat every 7-14 days.
Serenade ASO (*Bacillus subtilis*)	2-6 qts	0	4	?	Repeat on 2-10 day intervals as needed.
Serenade MAX (*Bacillus subtilis*)	1-3 lbs	0	4	?	Repeat on 2-10 day intervals as needed.
COPPER					Copper products have shown poor results in trials.
Badge *(copper oxychloride, copper hydroxide)*	0.75-1.25 lbs	-	48	3	Flecking may occur on spinach leaves.
Basic Copper 53 (*basic copper sulfate*)	2-4 lbs	Up to day of harvest	24	3	
Camelot O *(copper octanoate)*	0.5-2 gal/100 gal water applied at 50-100 gal	Up to day of harvest	4	3	Repeat at 7-10 intervals.
Champ WG *(copper hydroxide)*	1-1.58 lbs	-	48	3	Repeat at 7-10 day intervals as needed. Flecking may occur on spinach leaves.
Cueva Fungicide Concentrate *(copper octanoate)*	0.5-2.0 gal/100gal water	Up to day of harvest	4	3	Apply spray mix at 50 to 100 gallons per acre.
Nordox 75 WG (*cuprous oxide*)	1.25 – 2 lbs	-	12	3	Apply every 7 – 10 days.
Nu-Cop 50WP (*copper hydroxide*)	2 – 4 lbs	1	24	3	Apply every 7 – 10 days.
Nu-Cop HB *(cupric hydroxide)*	1-1.5 lbs	-	24	3	Repeat every 7-10 days.
OTHER					
EcoMate ARMICARB 0 *(potassium bicarbonate)*	2.5-5.0 lbs/100 gal water	0	4	?	
Milstop (*potassium bicarbonate*)	2-5 lbs	0	1	?	
OxiDate Broad Spectrum (*hydrogen*	40- 128 fl oz/100 gallons	0	Until spray has dried	?	Apply 30-100 gallons of spray solution per acre. See label for specific use

Table 11.2 Pesticides Labeled for Management of Downy Mildew					
CLASS OF COMPOUND Product name *(Active ingredient)*	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
peroxide/dioxide)					instructions.
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*	128 fl oz/100 gals water (curative) 32 fl oz/100 gals water (preventative)	0	Until dry	?	Apply 30-100 gals spray solution per treated acre. Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce to preventative rate after completion of the third treatment and maintain interval until harvest.
Sporatec *(rosemary, clove and thyme oils)*	1-3 pints in 100 gal spray	0	0	?	25(b) pesticide. Applications should be made once the disease is observed.
PERpose Plus (*hydrogen peroxide/dioxide*)	1 fl oz/gal (initial/curative) 0.25-0.33 fl oz/gal (weekly/preventative)	-	1 (interior); until dry (field)	?	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.
Trilogy (*neem Oil*)	.5-1-2% solution	Up to day of harvest	4	?	Apply using 25-100 gal water with a maximum of 2 gal/acre/application.

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

11.3 White Rust, *Albugo occidentalis*

Time for concern: Season long, especially if over-wintered inoculum source is present. Disease is favored by warm (72°), sunny days followed by cool nights with dew. Spores are more viable when they experience a period of drying but will not germinate until leaves are wet.

Key characteristics: Oospores may survive one year or more in New York in soil and infested crop debris, leading to primary infection of leaves closest to the soil. Symptoms of this fungus are small yellow spots on upper leaf surfaces and white pustules most commonly on lower leaf surfaces and petioles. As disease develops, pustules release spores that create secondary infections in other plants if conditions are favorable for spore germination. Different races can occur. See Cornell photo (Reference 57), and University of Illinois factsheet (Reference 60).

Relative risk: Considered a sporadic but very important disease of spinach because spots reduce crop quality and can make spinach unmarketable (See Section 9: *Harvesting*, for grading standards).

Management Option	Recommendation for White Rust
Site selection	Do not plant spring crop near over-wintered fields.
Crop rotation	A three-year crop rotation will reduce pathogen inoculum.
Resistant varieties	Plant resistant varieties (see Section 6: *Varieties*).
Seed selection	Fungus is not seed borne but may occur as a surface contaminant of seed produced in the eastern United States. However, most seed is grown in the western U.S. where white rust does not occur. If contamination is suspected, chlorine or hot-water seed treatment may be necessary, but check

Management Option	Recommendation for White Rust
	with your certifier for restrictions on use of chlorine.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production.
Weed control	The only other known host of this species of white rust is Strawberry Blite, *Chenopodium capitatum* (L.) Asch.
Harvest	Use clean packing crates, boxes, etc. to avoid adding inoculum or new races of rust to the field. Use clean harvesting knives and equipment.
Postharvest	Deep plowing will speed rotting of infected plant debris.

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref 2). ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.

Table 11.3 Pesticides Labeled for Management of White Rust

CLASS OF COMPOUND **Product name** ***(Active ingredient)***	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
BIOLOGICALS					
Regalia Biofungicide (*Reynoutria sachalinensis)*	0.5 – 4 qts	0	4	?	Apply using 50-100 gallons of water per acre.
Serenade ASO (*Bacillus subtilis*)	2-6 qts	0	4	?	Repeat on 2-10 day intervals as needed.
Serenade MAX (*Bacillus subtilis*)	1-3 lbs	0	4	?	Repeat on 2-10 day intervals as needed.
BOTANICALS					
Trilogy *(neem oil)*	0.5-1% solution	Up to day of harvest	4	?	Use in 25 -100 gal per acre. Maximum use of 2 gal/acre/application.
COPPER					Copper products effective in 1/1 trial.
Badge *(copper oxychloride, copper hydroxide)*	0.75-1.25 lbs	-	48	1	Flecking may occur on spinach leaves.
Basic Copper 53 *(basic copper sulfate)*	2-4 lbs	Up to day of harvest	24	1	Flecking may occur on spinach leaves.
Camelot O *(copper octanoate)*	0.5-2 gal/100 gal water applied at 50-100 gal	Up to day of harvest	4	1	
Champ WG *(copper hydroxide)*	1-1.58 lbs	-	48	1	Repeat at 7-10 day intervals as needed. Flecking may occur on spinach leaves.
CS 2005 *(copper sulfate pentahydrate)*	19.2-25.6 oz	-	48	1	Flecking may occur on spinach leaves.
Cueva Fungicide Concentrate *(copper octanoate)*	0.5-2.0 gal/100gal water	Up to day of harvest	4	1	Apply spray mix at 50 to 100 gallons of per acre.
Nordox 75 WG (*cuprous oxide*)	1.25 – 2 lbs	-	12	1	Apply every 7 – 10 days.

Table 11.3 Pesticides Labeled for Management of White Rust					
CLASS OF COMPOUND **Product name** ***(Active ingredient)***	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
Nu-Cop 50DF *(copper hydroxide)*	2-3 lbs	1	24	1	Flecking may occur on spinach leaves.
Nu-Cop 50WP (*copper hydroxide*)	2 – 4 lbs	1	24	1	Apply every 7 – 10 days.
Nu-Cop HB *(cupric hydroxide)*	1-1.5 lbs	-	24	1	Repeat at 7-10 day intervals as needed.
HYDROGEN DIOXIDE					
OxiDate Broad Spectrum *(hydrogen dioxide)*	40-128 fl oz/100 gal water	0	Until sprays have dried	3	Oxidate not effective in 1/1 trial. Apply in 30-100 gallons of spray solution per acre. See label for specific use instructions.
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*	128 fl oz/100 gal (curative) 32 fl oz/100 gal (preventative)	0	Until spray has dried	?	Apply 30-100 gals spray solution per treated acre. Begin applications at curative rate, reduce to preventative rate after three applications.
PERpose Plus (*hydrogen peroxide/dioxide*)	1 fl oz/gal (initial/curative) 0.25-0.33 fl oz/gal (weekly/pre-ventative)	-	1 (interior); until dry (field)	3	Hydrogen peroxide products effective in 0/1 trial. 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.
OTHER					
Micro Sulf *(sulfur)*	4-6 lbs	-	24	?	Repeat at 7-10 day intervals as needed.
Sporatec *(rosemary, clove and thyme oils)*	1-3 pints in 100 gal spray	0	0	?	25(b) pesticide. Applications should be made once the disease is observed.

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

11.4 Cucumber Mosaic Virus

Time for concern: When winged aphid populations peak, usually late summer.

Key characteristics: Aphids spread Cucumber Mosaic Virus (CMV), or 'Spinach Blight'. More than 775 plant species host this virus, including many common crops and weeds. Aphids acquire and transmit CMV when they feed, even briefly, moving the virus quickly from infected to uninfected plants as the aphids migrate through weeds and fields. Weedy areas adjacent to fields serve are of great concern as a source of CMV. Infested aphids do not usually colonize spinach, and do not need to do so to spread the virus from infected plants to healthy plants. Infected plants show severe mosaic symptoms, stunting, and underdevelopment. When temperatures remain above 80^{o}F, symptoms develop faster and crown necrosis will occur even in resistant varieties. See Cornell photo (Reference 61) and factsheet (Reference 62).

Relative risk: CMV is unlikely to develop on early season spinach. However, if CMV reservoir is nearby and aphids are present, later crops will be affected; transmission will be key.

Management Option	Recommendation for Cucumber Mosaic Virus
Site selection	Avoid planting fields immediately downwind of any barrier. Hedgerows, wood lots, or hilly terrain reduce wind velocity and increase the number of aphids that then disperse into fields.
Crop rotation	Avoid planting spinach near cucumber mosaic virus susceptible vegetables such as tomatoes and cucurbit crops.
Resistant varieties	Plant resistant varieties (see Section 6: Varieties). Good resistance to CMV is available, but this resistance may be compromised at temperatures above 80°F.
Seed selection	Plant clean seed; CMV can be seed-borne.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production. It is not possible to control CMV by managing aphids because they transmit the virus so quickly.
Sanitation	Manage weed hosts especially chickweed, pokeweed, milkweed, buckhorn plantain and broadleaf plantain growing in or nearby the field.

11.5 Anthracnose *Colletotrichum dematium* f. sp. *spinaciae*

Time for concern: Fall plantings are more susceptible to this disease, which is favored by wet conditions and cooler temperatures (50-68°F).

Key characteristics: This fungus overwinters in a vegetative state on infected plant debris; splashing rain spreads spores to healthy plants. Symptoms of this disease are small, round, water-soaked spots on leaves. These spots develop into larger yellow or tan areas with distinct margins that coalesce to form brown lesions that become thin and dry like paper. Tiny black fruiting bodies on diseased tissue distinguish this pathogen from other leaf spot pathogens. Anthracnose often infects leaves that are already infected with other pathogens, especially white rust. See University of California fact sheet (Reference 64) and Washington State University slide show (Reference 65).

Relative Risk: Sporadic but can be serious in a wet season.

Management Option	Recommendation for Anthracnose
Site selection	Choose fields that have good air circulation. Fields surrounded by trees that slow air movement are at higher risk for infection due to the higher levels of moisture.
Crop rotation	A three-year crop rotation will reduce pathogen inoculum.
Resistant varieties	Plant resistant varieties once available (currently under development).
Seed selection	Use clean seed: anthracnose is a seed borne disease. If there is concern about contamination, treat seed with hot water or chlorine. Ask your certifier for possible restrictions on the use of chlorine.
Planting	Use practices that maximize air circulation around leaves and otherwise minimize leaf wetness. Orient rows parallel to the prevailing winds (normally in an east west direction). Use wide plant spacing; dense plantings favor disease development.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production.
Sanitation	Flip plow to bury infected debris. Eliminate volunteer spinach plants that can host anthracnose over the winter.
Note(s)	Maintain adequate fertility; low soil fertility favors this disease.

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Table 11.5 Pesticides Labeled for Management of Anthracnose

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Actinovate AG (*Streptomyces lydicus WYEC 108*)	3-12 oz/ (foliar spray)	0	1 or until solution has dried	?	Apply using 10-150 gallons of water per acre. The label recommends use of a spreader sticker for best results.
BOTANICALS					
Trilogy (*neem Oil*)	.5-1% solution	Up to day of harvest	4	?	Apply using 25-100 gal water with a maximum of 2 gal/A/application.
COPPER					
Badge (*copper oxychloride, copper hydroxide)*	0.75-1.25 lbs	-	48	?	Flecking may occur on spinach leaves.
Basic Copper 53 (*basic copper sulfate*)	2-4 lbs	Up to day of harvest	24	?	
Champ WG *(copper hydroxide)*	1-1.58 lbs	-	48	?	Repeat at 7-10 day intervals as needed. Flecking may occur on spinach leaves.
CS 2005 *(copper sulfate pentahydrate)*	19.2-25.6 oz	-	48	?	Flecking may occur on spinach leaves.
Nordox 75 WG (*cuprous oxide*)	1.25 – 2 lbs	-	12	?	Apply every 7 – 10 days.
Nu-Cop 50DF (*copper hydroxide*)	2-3 lbs	1	24	?	
Nu-Cop 50WP (*copper hydroxide*)	2 – 4 lbs	1	24	?	Apply every 7 – 10 days.
Nu-Cop HB *(cupric hydroxide)*	1-1.5 lbs	-	24	?	Repeat at 7-10 day intervals as needed.
OTHER					
EcoMate ARMICARB 0 *(potassium bicarbonate)*	2.5-5.0 lbs/100 gal water	0	4	?	
Milstop *(potassium bicarbonate)*	2-5 lbs	0	1	?	
PERpose Plus (*hydrogen peroxide/dioxide*)	1 fl oz/gal (initial/curative) 0.25-0.33 fl oz/gal (weekly/preventative)	-	1 (interior); until dry (field)	?	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.

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

11.6 Cladosporium Leaf Spot, *Cladosporium variabile*, Cercospora Leaf Spot, *Cercospora beticola, and* Stemphylium Leaf Spot, *Stemphylium botryosum f. sp. spinaciae*

Time for concern: These three fungal leaf spots can occur in the northeastern US, especially on overwintered spinach or spinach grown for seed.

Key characteristics: Symptoms are small, circular to oval spots that become tan, and then eventually gray with Cercospora leaf spot. Initially spots may be gray-green whereas they tend to be water-soaked with anthracnose. Older leaves are typically affected first. None of these pathogens produce tiny black fruiting bodies that are characteristic of anthracnose. *Cladosporium* produces dark green spores and fungal growth in the center of its leaf spots, which are smaller than the others and have a dark margin. The margin is diffuse with Stemphylium leaf spot and reddish brown with Cercospora leaf spot. Anthracnose spots enlarge more than the others and loose their circular appearance when they coalesce.

Relative Risk: All three leaf spots are considered of minor importance compared to anthracnose. Stemphylium and Cercospora leaf spots develop under warmer temperatures: 60-80 F and 75-80 F compared to 50-68 F for the other diseases.

Management: All three leaf spots are sufficiently similar to anthracnose that the same management practices are recommended (see Section 11.5 *Anthracnose*). All are seed-borne, need wet leaf tissue for infection, and can survive on infested debris. *Cercospora beticola* has a wider host range which includes other crops (mangel, red beet, Swiss chard, and sugarbeet), and weeds (common lambsquarter, redroot pigweed, mallow, and bindweed).

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref 2). **ALWAYS CHECK WITH YOUR CERTIFIER before using a new product**.

Table 11.6 Pesticides Labeled for Management of Leaf Spot

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Double Nickel 55 Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.25-3 lbs foliar spray	0	4	?	Repeat every 7-10 days or as needed. Labeled for Cercospora leaf spot only.
Double Nickel LC Biofungicide (*Bacillus amyloliquefaciens str. D747*)	0.5-6 qts as foliar spray	0	4	?	
Regalia Biofungicide *(Reynoutria sachalinensis)*	0.5-4 qt	0	4	?	Labeled for *Cercospora* leaf spot only. Apply in 50-100 gallons of water per acre.
COPPER					
Badge *(copper oxychloride, copper hydroxide)*	0.75-1.25 lbs	-	48	?	Flecking may occur on spinach leaves. Labeled for *Cercospora* leaf spot only
Basic Copper 53 (*basic copper sulfate*)	2-4 lbs	Up to day of harvest	24	?	Labeled for *Cercospora* leaf spot only.
Camelot O *(copper octanoate)*	0.5-2 gal/100 gal water applied at 50-100 gal/A	Up to day of harvest	4	?	Labeled for Cercospora leaf spot only.

Table 11.6 Pesticides Labeled for Management of Leaf Spot					
CLASS OF COMPOUND **Product name** ***(Active ingredient)***	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
Champ WG *(copper hydroxide)*	1-1.58 lbs	-	48	?	Repeat at 7-10 day intervals as needed. Labeled for *Cercospora* leaf spot only. Flecking may occur on spinach leaves.
CS 2005 *(copper sulfate pentahydrate)*	19.2-25.6 oz	-	48	?	Labeled for *Cercospora* leaf spot only. Flecking may occur on spinach leaves.
Cueva Fungicide Concentrate (*copper octanoate*)	0.5-2.0 gal/100gal water	Up to day of harvest	4	?	Labeled for *Cercospora* leaf spot only. Apply spray mix at 50 to 100 gallons per acre.
Nordox 75 WG (*cuprous oxide*)	1.25 – 2 lbs	-	12	?	Labeled for *Cercospora* leaf spot only. Apply every 7 – 10 days.
Nu-Cop 50DF (*copper hydroxide*)	2-3 lbs	1	24	?	
Nu-Cop 50WP *(copper hydroxide)*	2 – 4 lbs	1	24	?	Labeled for *Cercospora* leaf spot only. Apply every 7 – 10 days.
Nu-Cop HB *(cupric hydroxide)*	1-1.5 lbs	-	24	?	Repeat at 7-10 day intervals as needed.
OTHER					
Milstop (*potassium bicarbonate*)	2-5 lbs	0	1	?	Labeled for *Cercospora* leaf spot only.
PERpose Plus (*hydrogen peroxide/dioxide*)	1 fl oz/Gal (initial/curative) 0.25-0.33 fl oz/gal (weekly/preventative)	-	1 (interior); until dry (field)	?	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.
Trilogy (*neem Oil*)	.5-1% solution	1	4	?	Apply using 25-100 gal water with a maximum of 2 gal/A/application.

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

12. Nonpathogenic Disorders

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

Disorder	Description
Air pollution	Spinach is especially sensitive to ozone pollution. On the upper leaf surface this injury appears as stippling, bronzing or bleaching. Look for white, collapsed, irregular patches. See Ontario factsheet (Reference 66).
Bolting	Spinach bolts in response to long days and high temperatures. Try slow-bolting varieties or plant earlier.

13. INSECT MANAGEMENT

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

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

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

Natural Enemies

Learn to identify naturally occurring beneficial insects, and attract and conserve them in your fields by providing a wide variety of flowering plants in or near the field and by avoiding use of broad-spectrum insecticides during periods when natural enemies are present. In most cases, a variety of natural enemies are present in the field, each helping to reduce pest populations. The additive effects of multiple species of natural enemies, attacking different host stages, is more likely to make an important contribution to reducing pest populations than individual natural enemy species operating alone. Natural enemies need a reason to be present in the field, either a substantial pest population, alternative hosts, or a source of pollen or nectar, and may not respond to a buildup of pests quickly enough to keep pest populations below damaging levels. Releasing insectary-reared beneficial organisms into the crop early in the pest outbreak may help control some pests but sometimes these biocontrol agents simply leave the area. For more information, see Cornell's Natural Enemies of Vegetable Insect Pests (Reference 67) and A Guide to Natural Enemies in North America (Reference 68).

Regulatory

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

Efficacy

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

Resources:

Natural Enemies of Vegetable Insect Pests (Reference 67).
Biological Control: A Guide to Natural Enemies in North America (Reference. 68).
Resource Guide for Organic Insect and Disease Management (Reference 3).

Table 13. Pesticides Labeled for Insect Control in Organic Spinach

CLASS OF COMPOUND **Product name** *(Active ingredient)*	**Green Peach Aphid**	**Leafminer**	**Cabbage Looper**	**Flea Beetle**
BIOLOGICAL				
Agree WG (*Bacillus thuringiensis aizawai str. GC-91*)			X	
Biobit HP (*Bacillus thuringiensis subsp. kurstaki*, str. ABTS-351)			X	
Deliver (*Bacillus thuringiensis kurstaki*)			X	
DiPel DF (*Bacillus thuringiensis kurstaki*)			X	
Entrust Naturalyte Insect Control (*spinosad*)		X	X	

Table 13. Pesticides Labeled for Insect Control in Organic Spinach				
CLASS OF COMPOUND **Product name** *(Active ingredient)*	**Green Peach Aphid**	**Leafminer**	**Cabbage Looper**	**Flea Beetle**
Entrust SC (*spinosad*)		X	X	
Grandevo *(Chromobacterium subtsugae str. PRAA4-1)*	X		X	
Javelin WG (*Bacillus thuringiensis kurstaki*)			X	
Mycotrol O *(Beauveria bassiana)*	X		X	X
PFR-97 20% WDG *(Isaria fumosorosea Apopka str. 97)*	X			
XenTari (*Bacillus thuringiensis aizawai*)			X	
BOTANICAL				
Aza-Direct (*azadirachtin*)	X	X	X	X
Azaguard (*azadirachtin)*	X	X	X	X
AzaMax (*azadirachtin)*	X	X	X	X
Azatrol EC *(azadirachtin)*	X	X	X	X
Azera *(azadirachtin)*	X		X	X
BioLink *(garlic juice)*	X	X	X	X
BioRepel *(garlic oil)*	X			
Cedar Gard *(cedar oil)*		X		X
Ecotec *(rosemary and peppermint oil)*	X		X	X
Ecozin Plus (*azadirachtin*)	X	X	X	X
GC-Mite (*cottonseed,clove and garlic oils)*	X			
Garlic Barrier AG *(garlic juice)*	X	X	X	
Molt-X *(azadirachtin)*	X	X	X	X
Neemazad 1% EC (*azadirachtin)*	X	X		
Neemix 4.5 (*azadiractin*)	X	X	X	X
PyGanic EC 1.4$_{II}$ (*pyrethrin*)	X	X	X	X
PyGanic EC 5.0 $_{II}$ (*pyrethrin*)	X	X	X	X
Surround WP (*kaolin*)				X
Trilogy (*neem oil*)	X			
OILS				
Golden Pest Spray Oil *(soybean oil)*	X	X		
OTHER				
M-Pede (*potassium salts of fatty acids*)	X			
Sil-Matrix (*potassium silicate*)	X			
SucraShield (*sucrose octanoate esters*)	X		X	

At the time this guide was produced, the previous materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref. 2). **ALWAYS CHECK WITH YOUR CERTIFIER before using a new product.**

13.1 Green Peach Aphid *Myzus persicae*

Time for concern: Seedling stage through harvest. Aphid populations peak in late summer but need to be monitored beginning early in the season.

Key characteristics: Green peach aphids are approximately 1/16 inch long and vary in color. Both winged and wingless forms are produced. Aphids distort plant growth by sucking plant juices and can transmit cucumber mosaic virus (See Section 11.4). Aphids and some beneficial insects that they attract are considered contaminants at harvest. See Cornell aphid fact sheet (Reference 69).

Relative risk: Later planting dates are at higher risk for damage by aphids and infection with cucumber mosaic virus. Plan ahead to determine market tolerance for aphid contamination in harvested crop. Aphids are not usually a problem in organic systems, where broad-spectrum insecticides are rarely used. They may be more of a problem for spinach grown in high tunnels.

Management Option	Recommendation for Aphids
Site selection	If possible, establish spinach fields upwind of weedy border areas to minimize colonization by downwind dispersal of winged aphids. Later planted fields should be placed on the upwind side of established fields to minimize the introduction of CMV by aphids dispersing from older possibly infected fields.
Scouting	Early detection is important. Fields should be checked regularly for presence of aphids. The following guidelines have been developed in Delaware and may be applied here. Check 10 plants in 10 locations throughout the field for the presence of aphids. Examine top and bottom leaf surfaces. For smaller fields check 5 plants at up to 5 locations throughout the planting. Thresholds: On seedling stage spinach, controls should be applied if one aphid per plant is found. In established fields, apply treatments if 4-10 aphids per plant are found.
Cultural controls	Mulches: Aluminized reflective mulches may slow down colonization of plants by winged aphids. Direct seeding or transplanting through the foil is recommended for maximum protection. Vacuum/leaf blower: Aphids can be vacuumed from leaves using a retail or commercial-duty leaf blower operated for suction.
Biological controls	Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. See Guide to Natural Enemies in North America (Reference 68) for identification of natural enemies. Releasing lacewing larvae might be economically viable if aphid populations are high enough to contaminate crop at harvest.
Floating row covers	Floating row covers can be used as a barrier to aphid infestation provided that they are installed prior to migration of winged aphids into the area. Row covers can remain in place until harvest. See Cornell insect traps and barriers factsheet (Reference 71) for more on row covers.
Harvest	Harvest the crop as early as possible to minimize vulnerability to late-season aphid colonization and virus infection.
Sanitation	Maintain effective management of weeds in and on the margins of fields. Eliminate volunteer plants and rogue diseased plants.
Note(s)	Aphid populations may decline rapidly during periods of heavy rainfall.

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System [(PIMS) website] (Ref. 2). **ALWAYS CHECK WITH YOUR CERTIFIER** before using a new product.

Table 13.1 Pesticides Labeled for Management of Green Peach Aphid

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Grandevo *(Chromobacterium subtsugae str. PRAA4-1)*	2-3 lbs	0	4	?	
Mycotrol O (*Beauveria bassiana*)	0.25 to 1 qt	Up to day of harvest	4	2	Beauveria products effective in 4/9 trials.
PFR-97 20% WDG *(Isaria fumosorosea Apopka str. 97)*	1-2 lbs	-	4	?	Repeat applications at 3-10 day intervals as needed to maintain control.
BOTANICALS					
azadirachtin					Azadirachtin based products effective in 4/7 trials.
Aza-Direct	1-2 pts	0	4	1	Up to 3.5 pts can be used under extreme pest pressure
AzaGuard	10-16 fl oz	0	Until sprays have dried	1	Apply with OMRI approved spray oil.
AzaMax	1.33 fl oz/1000 ft^2 (spray)	0	4	1	
Azatrol EC	0.24-0.96 fl oz/1000 ft2	0	4	1	
Azera *(azadirachtin)*	32 fl oz	-	12	1	
Ecozin Plus	15-30 oz	0	4	1	Will not control adults
Molt-X	10 oz	0	4	1	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemazad 1% EC	22.5 -31.5 fl oz	Not listed	4	1	Suppression and adult feeding deterrence.
Neemix 4.5	5-7 fl oz	0	4	1	Suppresses populations, deters adult feeding.
pyrethrin					Pyrethrin based products effective in 1/3 trials.
PyGanic EC 1.4 $_{II}$	16-64 fl oz	0	12	2	
PyGanic EC 5.0 $_{II}$	4.5-17 fl oz	0	12	2	
garlic					
BioLink *(garlic juice)*	0.5-2 qts	-	-	?	25(b) pesticide. Repellant.
Garlic Barrier AG (*garlic juice*)	1-2% solution	-	4	?	25(b) pesticide. Repellant. For 1% solution: 1gal/99 gal water mix, spray at 10 gal mix/A.
Other botanical					
Ecotec *(rosemary and peppermint oil)*	1-4 pts in 100 gal spray	0	-	?	25(b) pesticide
Trilogy (*neem oil*)	1-2% solution	1	4	?	Apply using a minimum of 25 gal water.

Table 13.1 Pesticides Labeled for Management of Green Peach Aphid					
CLASS OF COMPOUND **Product name** ***(Active ingredient)***	**Rate/A**	**PHI (Days)**	**REI (hours)**	**Efficacy**	**Comments**
OILS					
BioRepel *(garlic oil)*	1 part BioRepel/ 100 parts water	-	-	?	25(b) pesticide. Repellant.
GC-Mite (*cottonseed,clove and garlic oils)*	1gal/100 gal water spray to cover surface	-	-	?	25(b) pesticide
Golden Pest Spray Oil (*soybean oil*)	2 gal	-	4	?	
Organocide 3-in-1 (*sesame oil*)	1-2 gal/100 gal water	-	-	?	25(b) pesticide
OTHER					
M-Pede (*potassium salts of fatty acids*)	1-2% volume to volume solution	0	12	3	Soap based products not effective in 9/9 trials. Must be tank mixed with another labeled companion insecticide.
Sil-Matrix (*potassium silicate*)	2 – 4 qts/100 gals	0	4	?	Apply at 20 gallons finished spray/A.
SucraShield (*sucrose octanoate esters*)	0.8-1% vol to vol solution	0	48	?	Use between 25 and 400 gal per acre of mix per acre.

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

13.2 Spinach Leafminer, *Pegomyia hyoscyami*

Time for concern: During seedling development in spring and summer plantings

Key characteristics: The adult spinach leafminer fly is 1/4 inch long and gray with black bristles. It lays 1 mm long white eggs on the undersides of leaves in mid-spring. The legless, yellowish white larva burrows between leaf layers as it feeds. Damage appears as blisters on the surface of the leaves. The mature larva cuts a hole in the leaf, drops to the ground to pupate and emerges 2-4 weeks later as an adult fly. In temperate areas, several generations may be produced per year; spinach leafminers overwinter as pupae in the soil or in plant debris to emerge the following spring as adult flies. See the Colorado State University photo of damage (Reference 72), Cornell photo of eggs (Reference 73) and USDA photos of adult and larva (Reference 74).

Relative risk: Very early spring plantings and fall plantings tend to escape damage. Most commercial growers would be concerned if more than 5% of harvested leaves had leaf miner injury, but some markets may have a higher tolerance.

Management Option	Recommendation for Spinach Leafminer
Site selection	Choose a site free from weed hosts, including lambsquarter, nightshade, chickweed, and plantain. Do not plant close to beets, Swiss chard or other spinach fields.
Crop rotation	Beets, Swiss chard, and spinach are all hosts for the spinach leafminer. Rotate away from these crops for 2-3 years.
Resistant varieties	Varieties with resistance are not yet market ready, but have been developed and distributed to breeders and researchers who will incorporate them into breeding programs to add leafminer resistance to popular varieties. Look for varieties with resistance in the near future. (Reference 74)
Planting	Spinach leafminer flies overwinter in the pupal stage in or near spinach fields; adult flies emerge in April and May to lay eggs. Spinach planted very early in the current year or overwintered spinach planted the previous fall will escape most leafmining damage if harvested prior to mid-May.
Scouting/thresholds	Early detection is important. Check young seedlings weekly for mining on the cotyledons and first true leaves. Examine 10 plants in 10 locations. Be sure to examine the undersurface of the leaves where

Management Option	Recommendation for Spinach Leafminer
	mines are most obvious. Look for mines and newly hatching larvae. Thresholds: Thresholds have not been established in NY for organic production. In Delaware they are using the following thresholds: Treatment should be applied when you find eggs or mines on 50% of the plants or if you find an average of one or more mines per leaf. As a field approaches harvest, treatments should be applied so that no more than 5% of the leaves have mines.
Yellow traps	Yellow sticky traps help determine when adult flies are emerging and will also reduce actual numbers of adult flies in the field.
Weed control	Remove weed hosts, including lambsquarter, nightshade, chickweed, and plantain.
Cultural controls	Deep-spring plowing will reduce overwintering leafminers. Planting very early in spring or late fall will reduce exposure to leafminers.
Biological controls	Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. See Guide to natural enemies in North America (Reference 68) for identification of natural enemies.
Mechanical controls	In smaller plantings, row covers can be used as a barrier to egg-laying adults, provided that they are installed at planting and the edges are well anchored to prevent adult flies from entering. Row covers can remain in place until harvest. Do not use row covers on soil that may harbor overwintering leafminers from the previous season. See Cornell insect traps and barriers factsheet (Reference 71). Pick and destroy leaves with mining damage before the larvae emerge to limit future generations.
Chemical controls	Initiate treatment when thresholds are reached.

At the time this guide was produced, the following materials were labeled in New York State for managing this pest and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System (PIMS) website (Ref 2). **ALWAYS CHECK WITH YOUR CERTIFIER** before using a new product.

Table 13.2 Pesticides Labeled for Management of Spinach Leafminer

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Entrust Naturalyte Insect Control (*spinosad*)	2-3 oz	1	4	1	Will penetrate leaves and therefore has activity against some leafminers. Efficacy improves with addition of adjuvant. May provide incidental control of flea beetles.
Entrust SC (*spinosad*)	4-10 fl oz	1	4	1	Will penetrate leaves and therefore has activity against some leafminers. Efficacy improves with addition of adjuvant. May provide incidental control of flea beetles.
BOTANICALS					
azadirachtin					Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops.
Aza-Direct	1-2 pts	-	4	3	
AzaGuard	10-16 fl oz	0	Until spray has dried	3	Apply with OMRI approved spray oil.
AzaMax	1.33 fl oz/1000 ft^2	0	4	3	
Azatrol EC	0.24-0.96 fl oz/1000 ft^2	0	4	3	
Ecozin Plus	15-30 oz	0	4	3	

Table 13.2 Pesticides Labeled for Management of Spinach Leafminer					
CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
Molt-X	10 oz	0	4	3	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemazad 1% EC	18 -72 fl oz	-	4	3	Target insect larvae
Neemix 4.5	4-7 fl oz	0	4	3	
pyrethrins					
PyGanic EC 1.4 II	16-64 fl oz	0	12	?	
PyGanic EC 5.0 II	4.5-17 fl oz	0	12	?	
garlic					
BioLink *(garlic juice)*	0.5-2 qts	-	-	?	25(b) pesticide. Repellant.
Garlic Barrier AG *(garlic juice)*	1-2%	-	4	?	25(b) pesticide. Repellant. For 1% solution: 1gal/99 gal water mix, spray at 10 gal mix/A.
OILS					
Cedar Gard *(cedar oil)*	1 qt	-	-	?	25(b) pesticide.
Golden Pest Spray Oil (*soybean oil*)	2 gal	-	4	?	

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

13.3 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 feed on spinach leaves for 2-4 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 76), University of Illinois photos (Reference 77) and References 4 and 78.

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/early August. Spinach planted very early in the current year or overwintered spinach planted the previous fall will escape most cabbage looper damage if harvested prior to mid-May.
Scouting	The following guidelines have been developed in Virginia (Reference 6) and may be applied here. Monitor ten random spinach plants from ten separate locations biweekly. Scout for presence of eggs and early instar larvae. Thresholds: Treatment is recommended if one larva per ten plants is found on seedlings or one larva per two plants on established plants.

Management Option	Recommendation for Cabbage Looper
Traps	Bucket-type pheromone (or UV light traps) traps can be used to monitor moth flight. See Reference 80 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	Early harvest of over wintered or early spring planted spinach can minimize damage from cabbage loopers, which are generally not a problem until late summer.
Biological controls	Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. See Guide to natural enemies in North America (Reference 68) for identification of natural enemies.
Floating row covers	For smaller plantings, row covers can be used as a barrier to egg-laying adults, provided that 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 71) 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.
Chemical controls	All chemical controls listed below are larvicides and must be ingested to be effective.

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Table 13.3 Pesticides Labeled for Management of Cabbage Looper

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Bacillus thuringiensis					Bt products effective in 6/7 trials.
Agree WG (*Bacillus thuringiensis aizawai strain GC-91*)	0.5-2 lbs	Up to day of harvest	4	1	Good coverage is essential.
Biobit HP (*Bacillus thuringiensis subsp. kurstaki*, str. ABTS-351)	0.5-1 lb	0	4	1	Good coverage is essential.
XenTari (*Bacillus thuringiensis aizawai*)	0.5-1.5 lbs	0	4	1	.
Deliver (*Bacillus thuringiensis kurstaki*)	0.25-1.5 lbs	0	4	1	
DiPel DF (*Bacillus thuringiensis kurstaki*)	0.5- 1 lb	0	4	1	
Javelin WG (*Bacillus thuringiensis kurstaki*)	0.12-1.5 lbs	0	4	1	
Beauveria bassiana					
Mycotrol O (*Beauveria bassiana*)	0.25 to 1 qt	Up to day of harvest	4	?	
Chromobacterium					
Grandevo (*Chromobacterium subtsugae str. PRAA4-1*)	1-3 lbs	0	4	?	

Table 13.3 Pesticides Labeled for Management of Cabbage Looper

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
spinosad					
Entrust Naturalyte Insect Control (*spinosad*)	1-2 oz	1	4	1	Effective in 41/47 trials against caterpillars including cabbage looper. May provide incidental control of flea beetles when applied for loopers.
Entrust SC (*spinosad*)	3-6 fl oz	1	4	1	Will penetrate leaves and therefore has activity against some leafminers. Efficacy improves with addition of adjuvant. May provide incidental control of flea beetles.
BOTANICALS					
pyrethrins					Pyrethrum products effective in 1/1 trial.
PyGanic EC 5.0 II	4.5-17 fl oz	0	12	1	
PyGanic EC 1.4 II	16-64 fl oz	0	12	1	
azadirachtin					Azadirachtin-based products effective in 2/4 trials.
Aza-Direct	1-2 pts	0	4	1	Up to 3.5 pts can be used under extreme pest pressure.
AzaGuard	8-16 fl oz	0	Until spray has dried	1	Apply with OMRI approved spray oil.
AzaMax	1.33 fl oz/1000 ft^2	0	4	1	
Azatrol EC	0.19-0.96 fl oz/1000 ft2	0	4	1	
Azera	32 fl oz	-	12	1	
Ecozin Plus	15-30 oz	0	4	1	Will not control adults
Molt-X	8 oz	0	4	1	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemix 4.5	7-16 fl. oz	0	4	1	
garlic					
BioLink *(garlic juice)*	0.5-2 qts	-	-	?	25(b) pesticide.
Garlic Barrier AG repellent (99.3% *garlic juice*)	1-2%	-	4	?	25(b) pesticide. Repellant. For 1% solution: 1gal/99 gal water mix, spray at 10 gal mix/A.
other botanicals					
Ecotec *(rosemary and peppermint oil)*	1-4 pts in 100 gal spray	0	-	?	25(b) pesticide
OTHER					
SucraShield (*sucrose octanoate esters*)	0.8-1% vol to vol solution	0	48	?	Use between 25 and 400 gal per acre of mix per acre.

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

13.4 Flea Beetles including Spinach Flea Beetle, *Disonycha xanthomelas*

Time for concern: May through harvest.

Key characteristics: Several species of flea beetles (family Chrysomelidae) can be a problem on spinach. These are active small insects with enlarged hind legs. Most species overwinter as adult beetles, emerging in the spring to feed on the upper and lower surfaces of foliage, and producing shothole-like feeding damage. In severe infestations, transplants and seedlings can be nearly totally defoliated, resulting in significant stand losses.

Relative risk: Spring plantings are at greater risk of infestation than late fall-planted (overwintered) spinach.

Management Option	Recommendation for Spinach Flea Beetle
Crop rotation	Beets, Swiss chard, and spinach are all hosts for the spinach flea beetle and for related species. Rotate away from these crops for 2-3 years.
Planting Methods	Overwintered spinach planted the previous fall is likely to escape most flea beetle injury if harvested prior to mid-May.
Scouting	Examine seedling and transplant foliage for shothole-like feeding injury.
Traps	Yellow sticky traps or ribbons placed near foliage may help determine when adult beetles emerge and are active.
Weed Control	Remove broadleaf weed hosts, including lambsquarter, nightshade, chickweed, and plantain.
Cultural Controls	Deep-spring plowing may introduce mortality in overwintering adult beetles.
Biological Controls	Naturally-occurring predators, parasitoids, and pathogens help suppress infestations. See Guide to natural enemies in North America (Reference 68) for identification of natural enemies.
Floating row covers	Row covers can be used as a barrier provided that they are installed at planting and the edges are well anchored to prevent beetles from entering. Row covers can remain in place until harvest. Do not use row covers on soil that may harbor overwintering flea beetles from the previous season. See Cornell insect traps and barriers factsheet (Reference 71) for more on row covers.
Vacuum/leaf blower	Flea beetles can be vacuumed from leaves using a retail or commercial-duty leaf blower operated for suction.
Chemical controls	Initiate control when visual inspection reveals feeding damage that may trigger grading defects and/or marketing problems.

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Table 13.4 Pesticides Labeled for Management of Spinach Flea Beetle

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
BIOLOGICALS					
Mycotrol O *(Beauveria bassiana)*	0.25 to 1 qt.	Up to day of harvest	4	2	
BOTANICALS					
pyrethrins					
PyGanic EC 5.0 II	4.5 -17 fl oz	0	12	2	
PyGanic EC 1.4 II	16 – 64 fl oz	0	12	2	
azadirachtin					Azadirachtin based products effective in 1/3 trials.
Aza-Direct	1-2 pts	0	4	2	Larvicide; may suppress adult feeding.

Table 13.4 Pesticides Labeled for Management of Spinach Flea Beetle

CLASS OF COMPOUND Product name *(Active ingredient)*	Rate/A	PHI (Days)	REI (hours)	Efficacy	Comments
AzaGuard	8-16 fl oz	0	Until spray has dried	2	Apply with OMRI approved spray oil.
AzaMax	1.33 fl oz/1000 ft^2	0	4	2	
Azatrol EC	0.24-0.96 fl oz/1000 ft^2	0	4	2	
Azera	32 fl oz	-	12	2	
Ecozin Plus	15-30 oz	0	4	2	Larvicide; may suppress adult feeding.
Molt-X	8 oz	0	4	2	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves.
Neemix 4.5	7-16 fl. oz	0	4	2	Larvicide; may suppress adult feeding.
other botanicals					
BioLink *(garlic juice)*	0.5-2 qts	-	-	?	25(b) pesticide.
Ecotec *(rosemary and peppermint oil)*	1-4 pts in 100 gal spray	0	-	?	25(b) pesticide
OTHER					
Cedar Gard *(cedar oil)*	1 qt	-	-	?	25(b) pesticide
Surround WP (*kaolin*)	25 – 50 lbs	Up to day of harvest	4	3	Surround effective in 0/4 trials.

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

14. PESTICIDES AND ABBREVIATIONS MENTIONED IN THIS PUBLICATION

Table 14.1 Insecticides and molluscides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Agree WG	*Bacillus thuringiensis aizawai str. GC-91*	70051-47
Aza-Direct	*azadirachtin*	71908-1-10163
AzaGuard	*azadiracthin*	70299-17
AzaMax	*azadiracthin*	71908-1-81268
Azatrol EC	*azadiracthin*	2217-836
Azera	*azadiracthin*	1021-1872
Biobit HP	*Bacillus thuringiensis subsp. kurstaki*, str. ABTS-351	73049-54
BioLink	*garlic juice*	Exempt 25(b) pesticide
BioRepel	*garlic oil*	Exempt 25(b) pesticide
Cedar Gard	*cedar oil*	Exempt 25(b) pesticide
Deliver	*Bacillus thuringiensis kurstaki*	70051-69
DiPel DF	*Bacillus thuringiensis kurstaki*	73049-39
Ecotec	*rosemary and peppermint oil*	Exempt 25(b) pesticide
Ecozin Plus	*azadirachtin*	5481-559
Entrust Naturalyte Insect Control	*spinosad*	62719-282
Entrust SC	*spinosad*	62719-621
Garlic Barrier AG+	*garlic juice*	Exempt 25(b) pesticide
GC-Mite	*cottonseed, clove, and garlic oils*	Exempt 25(b) pesticide
Golden Pest Spray Oil	*soybean oil*	57538-11
Grandevo	*Chromobacterium subtsugae str. PRAA4-1*	84059-17
Javelin WG	*Bacillus thuringiensis kurstaki*	70051-66

Table 14.1 Insecticides and molluscides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Molt-X	*azadirachtin*	68539-11
M-Pede	*potassium salts of fatty acids*	10163-324
Mycotrol O	*Beauveria bassiana*	82074-3
Neemazad 1% EC	*azadirachtin*	70051-104
Neemix 4.5	*azadirachtin (neem)*	70051-9
PFR-97 20% WDG	*Isaria fumosorosea Apopka str. 97*	70051-19
PyGanic Crop Protection EC 1.4 II	*pyrethrin*	1021-1771
PyGanic Crop Protection EC 5.0 II	*pyrethrin*	1021-1772
Sil-Matrix	*potassium silicate*	82100-1
SucraShield	*sucrose octanoate esters*	70950-2-84710
Surround WP	*kaolin*	61842-18
Trilogy	*neem oil*	70051-2
XenTari	*Bacillus thuringiensis aizawai*	73049-40

Table 14.2 Fungicides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Actinovate AG	*Streptomyces lydicus WYEC 108*	73314-1
Actino-Iron	*Streptomyces lydicus WYEC 108*	73314-2
Badge	*copper oxychloride, copper hydroxide*	80289-12
Basic Copper 53	*basic copper sulfate*	45002-8
BIO-TAM	*Trichoderma asperellum, Trichoderma gamsii*	80289-9-69592
Camelot O	*copper octanoate*	67702-2-67690
Champ WG	*copper hydroxide*	55146-1
CS 2005	*copper sulfate pentahydrate*	66675-3
Cueva Fungicide Concentrate	*copper octanoate*	67702-2-70051
Double Nickel 55 Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-108
Double Nickel LC Biofungicide	*Bacillus amyloliquefaciens str. D747*	70051-107
EcoMate ARMICARB 0	*potassium bicarbonate*	5905-541
Micro Sulf	*sulfur*	55146-75
Milstop	*potassium bicarbonate*	70870-1-68539
Mycostop Biofungicide	*Streptomyces griseoviridis strain K61*	64137-5
MycoStop Mix	*Steptomyces griseoviridis strain K61*	64137-9
Nordox 75 WG	*cuprous hydroxide*	48142-4
Nu-Cop 50 DF	*copper hydroxide*	45002-4
Nu-Cop 50 WP	*cupric hydroxide*	45002-7
Nu-Cop HB	*cupric hydroxide*	42750-132
OxiDate Broad Spectrum	*hydrogen dioxide*	70299-2
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*	68539-7
RootShield PLUS+ WP	*Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*	68539-9
RootShield Granules	*Trichoderma harzianum*	68539-3
RootShield PLUS+ Granules	*Trichoderma harzianum str. T-22, Trichoderma virens str. G-41*	68539-10
Serenade ASO	*Bacillus subtilis*	69592-12
Serenade MAX	*Bacillus subtilis*	69592-11
Serenade Soil	*Bacillus subtilis*	69592-12
SoilGard	*Gliocladium virens strain GL-21*	70051-3
Sporatec	*rosemary, clove and thyme oils*	Exempt 25(b) pesticide
Taegro Biofungicide	*Bacillus subtilis var. amyloliquefaciens strain FZB24*	70127-5
Trilogy	*neem oil*	70051-2

Table 14.3 Sanitizers mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
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
Pro Oxine	*chlorine dioxide*	9804-9
*SaniDate 5.0	*hydrogen peroxide/peroxyacetic acid*	70299-19
San-I-King No. 451	*sodium hypochlorite*	2686-20001
Tsunami 100	*hydrogen peroxide/peroxyacetic acid*	1677-164
Victory	*hydrogen peroxide/peroxyacetic acid*	1677-186
VigorOx Liquid Sanitizer and Disinfectant OAI	*hydrogen peroxide/peroxyacetic acid*	65402-6
VigorOx 15 F & V	*hydrogen peroxide/peroxyacetic acid*	65402-3
VigorOx LS-15	*hydrogen peroxide/peroxyacetic acid*	65402-3

* Restricted-use pesticide in New York State

Abbreviations and Symbols Used in This Publication

A	acre	N	nitrogen
AG	agricultural use label	NE	not effective
AR	annual rye	NI	no information
ASO	aqueous suspension-organic	NFT	not frost tolerant
DF	dry flowable	P	phosphorus
EC	emulsifiable concentrate	REI	restricted-entry interval
HC	high concentrate	WP	wettable powder
K	potassium	WG	water dispersible granular
K_2O	potassium oxide	WPS	Worker Protection Standard
		*	Restricted-use Pesticide

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