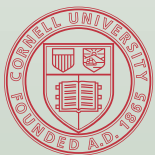


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Organic Production and IPM Guide for Spinach



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2016 PRODUCTION GUIDE FOR ORGANIC SPINACH

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

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

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

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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 Development/Assistance](#) (Reference 12). See more certification and regulatory details under Section 4.1 *Certification Requirements* and Section 10: *Using Organic Pesticides*.

1.2 Organic System Plan

An organic system plan (OSP) is central to the certification process. The OSP describes production, handling, and record-keeping systems, and demonstrates to certifiers an understanding of organic practices for a specific crop. The process of developing the plan can be very valuable in terms of anticipating potential issues and challenges, and fosters thinking of the farm as a whole system. Soil, nutrient, pest,

and weed management are all interrelated on organic farms and must be managed in concert for success. Certifying organizations may be able to provide a template for the farm plan. The following description of the organic system plan is from the USDA [National Organic Program Handbook](#) (Reference 13):

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

The [National Sustainable Agriculture Information Service](#), (formerly ATTRA), has produced a [Guide for Organic Crop Producers](#) that includes a chapter on writing the organic system plan (Reference 16). The [Rodale Institute](#) has also developed resources for transitioning to organic and developing an organic system 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 crop or crops that will be in place for one or more seasons, deprives many, but not all, disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. 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 overall 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 tillage, 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).

ORGANIC SPINACH PRODUCTION

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

SPECIES	PLANTING DATES	LIFE CYCLE	COLD HARDINESS ZONE	HEAT	DROUGHT	SHADE	pH PREFERENCE	SOIL TYPE PREFERENCE	SEEDING (lb/A)	NITROGEN FIXED (lb/A) ^a	COMMENTS
				TOLERANCES							
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. ^bWinter killed. Reprinted with permission from [Rodale Institute](#) 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 the 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

Crop	Nutrient Needs		
	Lower	Medium	Higher
	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.

[Organic Farms: A Planning Manual](#) edited by Charles L. Mohler and Sue Ellen Johnson (Reference 24).

See Table 4.2.2 for more crop rotation information specific for spinach. For more details, see [Crop Rotation on](#)

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 <i>increase</i>	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 <i>reduced</i>	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 <i>increase</i>	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 <i>decrease</i>	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, create an environment that favors prolonged leaf wetness. Plant rows parallel to the prevailing winds, which is typically in an east-west direction, and avoid overcrowding to promote drying of the soil and reduce moisture in the plant canopy.

5. WEED MANAGEMENT

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

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

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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

yellow 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

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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 <i>Basella alba</i>
New Zealand 'spinach'					X		52-70			OP, withstands frost to low 20's <i>Tetragonia tetragonioides</i>

(Adapted from Reference 56 Vegetable MD Online Spinach: Disease Resistance Table with additional information from seed companies Hy=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, sufficient soluble nutrients must be available from the soil to meet the minimum requirements for the whole plant. The total nutrient needs of a crop are much higher than just the nutrients that are removed from the field when that crop is harvested. All of the roots, stems, leaves and other plant parts require nutrients at specific times during plant growth and development. Restrictions in the supply of required plant nutrients will limit growth and reduce crop quality and yields.

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

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

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

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

Table 8.0.1 Nutrient Testing Laboratories.

TESTING LABORATORY	SOIL	COMPOST/ MANURE	REFERENCES
The Agro One Lab (Cornell Recommendations)	x	x	42
Agri Analysis, Inc.		x	39
A&L Eastern Ag Laboratories, Inc.	x	x	40
Cornell Soil Nutrient Analysis Lab	x		38
Penn State Ag Analytical Services Lab.	x	x	41
University of Massachusetts	x	x	43
University of Maine	x	x	44

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.

Develop a plan for estimating the amount of nutrients that will be released from soil organic matter, cover crops,

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

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

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

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

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

Table 8.2.1 Calculating Nutrient Credits and Needs.

	Nitrogen (N) lbs/A	Phosphate (P ₂ O ₅) lbs/A	Potash (K ₂ O) 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.

	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 ₂ O ₅ lbs/A			K ₂ O 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, 80% of the phosphorous and 90% of the potassium contained in most compost is available to the crop the first year. It is important to test each new mix of compost for actual amounts of the different nutrients available. Compost maturity will influence how much N is available. If the

material is immature, more of the N may be available to the crop in the first year. A word of caution: Using compost to provide for a crop’s nutrient needs is not generally a financially viable strategy. The high total volume needed, can be very expensive for the units of N available to the crop, especially if trucking is required. Most stable composts should be considered as soil conditioners, improving soil health, microbial diversity, tilth, and nutrient retaining capacity. Also keep in mind that manure-based composts are potentially high in salts that could become a problem if used yearly. Most compost analyses include a measure of electrical conductivity which indicates level of salts present in the finished product. Any compost applied on organic farms must be approved for use by your farm certifier. Compost generated on the farm must follow an approved process outlined by your certifier.

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

Line 4. Total Credits: Add together the various nutrient values from soil organic matter, compost, and cover crops to estimate the total nutrient supplying potential of the soil (see example below). There is no guarantee that these amounts will actually be available in the season, since soil temperatures, water, and crop physiology all impact the release and uptake of these soil nutrients. If the available N does not equal the minimum requirement for this crop (80-100 lbs/acre), a sidedress application of organic N may be needed. There are several sources for N for organic sidedressing (see Table 8.2.4) as well as pelleted composts. If early in the organic transition, a grower may consider increasing the N budget supply by 25%, to help reduce some of the risk of N being limiting to the crop.

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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 ₂ O ₅	K ₂ O	N1 ¹	N2 ²	P ₂ O ₅	K ₂ O
	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](#) 2015-2016 (Reference 46).

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

Table 8.2.4 Available Nitrogen in Organic Fertilizer

Sources	Pounds of Fertilizer/Acre to Provide X Pounds of N per Acre				
	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 ₂ O	500	1000	1500	2000	2500
Fish meal 9% N, also contains 6% P ₂ O ₅	220	440	670	890	1100
Alfalfa meal 2.5% N also contains 2% P and 2% K ₂ O	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

SOURCES	Pounds of Fertilizer/Acre to Provide X Pounds of P ₂ O ₅ Per Acre				
	20	40	60	80	100
Bonemeal 15% P ₂ O ₅	130	270	400	530	670
Rock Phosphate 30% total P ₂ O ₅ (x4) ^a	270	530	800	1100	1300
Fish meal , 6% P ₂ O 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.

SOURCES	Pounds of Fertilizer/Acre to Provide X Pounds of K ₂ O per acre:				
	20	40	60	80	100
Sul-Po-Mag 22% K ₂ O also contains 11% Mg	90	180	270	360	450
Wood ash (dry, fine, grey) 5% K ₂ O, also raises pH	400	800	1200	1600	2000
Alfalfa meal 2% K ₂ O also contains 2.5% N	1000	2000	3000	4000	5000
Greensand or Granite dust 1% K ₂ O (x 4) ^a	8000	16000	24000	32000	40000
Potassium sulfate 50% K ₂ O	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 P₂O₅/acre and 100 lbs K₂O/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 ₂ O ₅) lbs/acre	Potash (K ₂ O) 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.

Additional Resources

[Using Organic Nutrient Sources](#) (reference 25b)

[Determining Nutrient Applications for Organic Vegetables](#) (ref 25c)

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

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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 50) or the [Produce Safety Alliance](#) (Reference 50a). 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.

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

Table 9.3.1 Rates for Sanitizers for Postharvest 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
<i>chlorine dioxide</i>				
CDG Solution 3000	50 ppm solution	500 ppm dilution	-	5 ppm solution
Oxine ²	100 ppm solution	500 ppm solution	-	In tanks, use a 5 ppm solution; for process waters use a chemical feed pump or other injector system at 3 ¼ fl oz per 10 gal water. ³
Pro Oxine ²	50-200 ppm solution	500 ppm solution	-	-
<i>hydrogen peroxide/ peroxyacetic acid</i>				
Enviroguard Sanitizer	-	2.5-20 fl oz/5 gal water	1 fl oz/20 gal water	1 fl oz/20 gal water
Oxonia Active	1-1.4 oz/4 gal water	1 oz/8 gal water.	-	-
Peraclean 5	1-1.5 fl oz/5 gal water	-	-	-
Peraclean 15	0.33 fl oz/5 gal water	-	-	-
Perasan A	1-6.1 oz/6 gal	-	4 oz/20 gal water	-

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Table 9.3.1 Rates for Sanitizers 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
Per-Ox	1-2.25 fl oz/5 gal water	1-10 fl oz/15 gal water	1 fl oz/5 gal water	1 fl oz/5 gal water
SaniDate 5.0	1.6 fl oz/ 5 gal water	1.6 fl oz/ 5 gal water	59.1 to 209.5 fl oz/ 1,000 gallons water	59.1 to 209.5 fl oz/ 1,000 gallons water
SaniDate 12.0	-	-	25.6 to 89.6 fl oz / 1,000 gallons water	25.6 to 89.6 fl oz / 1,000 gallons water
Shield-Brite PAA 5.0	1.6fl oz/5 gal water	1.6fl oz/5 gal water	59.1 to 209.5 fl. oz./1,000 gal water	59.1 to 209.5 fl. oz./1,000 gal water
Shield-Brite PAA 12.0			25.6 to 107 fl.oz/1,000 gal water	25.6 to 107 fl.oz/1,000 gal water
StorOx 2.0	0.5 fl oz/1 gal water	0.5 fl oz/1 gal water	1:220 – 1:1,000 dilution (on process/packing line); .035-0.58 fl. oz./gal water (post-harvest spray treatment)	
Tsunami 100	-	-	2.5-6.7 fl oz/100 gal water	2.5-6.7 fl oz/100 gal water
Victory	-	-	1 fl oz/16.4 gal water	1 fl oz/16.4 gal water
VigorOx 15 F & V	0.31-0.45 fl oz/5 gal water-	1.1-9.5 fl oz/5 gal water -	1 fl oz/ 16 gal water as spray or dip	0.54 fl oz/ 16 gal water (processing water)
VigorOx LS-15	0.31-0.45 fl oz/5 gal water	1.1-9.5 fl oz/5 gal water	-	-
<i>sodium hypochlorite</i>				
San-I-King No. 451	100 ppm chlorine in solution	-	-	-

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

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](#) (Ref 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) are actually metabolic byproducts of the organism. Calculating nozzle discharge and travel speed are two key components required for applying an accurate pesticide dose per acre. Applying too much pesticide is illegal, can be unsafe and is costly whereas applying too little can fail to control pests or lead to pesticide resistance.

Resources

[Cornell Crop and Pest Management Guidelines: Pesticide Information and Safety](#) (Reference 51).
[Calibrating Backpack Sprayers](#) (Reference 52).
[Pesticide Environmental Stewardship: Calibration](#)(Reference 53).
[Knapsack Sprayers – General Guidelines for Use](#) (Reference 54)
[Pesticide Environmental Stewardship, Coop Extension](#) (reference 54a)
[Pesticide Environmental Stewardship, CIPM](#)(reference 54b)
[Vegetable Spraying](#) (reference 54c)

10.2 Regulatory Considerations

Organic production focuses on cultural, biological, and mechanical techniques to manage pests on the farm, but in some cases pesticides, which include repellents, allowed for organic production are needed. Pesticides mentioned in this organic production guide are registered by the United States Environmental Protection Agency (EPA) or meet the EPA requirements for a “minimum risk” pesticide. At the time of publication, the pesticides mentioned in this guide meet New York State Department of Environmental Conservation (NYS DEC) requirements for use in New York State. See Cornell’s [Product, Ingredient, and Manufacturer System](#) website (Link 2) for pesticides currently registered for use in NYS. Additional products may be available for use in other states.

To maintain organic certification, products applied must also comply with the National Organic Program (NOP) regulations as set forth in [7 CFR Part 205, sections 600-606](#) (Link 15). The [Organic Materials Review Institute](#) (OMRI) (Link 9) is one organization that reviews products for compliance with the NOP regulations and publishes lists of compliant products, but other entities also make product assessments. Organic growers are not required to use only OMRI listed materials, but the list is a good starting point when searching for allowed pesticides.

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

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

Do you need to be a certified pesticide applicator?

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

Worker Protection Standard training. If the farm has

employees who will be working in fields treated with a pesticide, they must be trained as workers or handlers as required by the federal Worker Protection Standard (WPS). Having a pesticide applicator certification is one of the qualifications needed to be a WPS trainer. Certified pesticide applicators meet the WPS training requirements. For more information on the Worker Protection Standard see: [How To Comply with the Worker Protection Standard](#) (Link 54d). See [Revisions To the Worker Protection Standard](#) for a summary of new worker protection standards that will take effect January 2017. Find more information on pesticide applicator certification from the list of [State Pesticide Regulatory Agencies](#) (Link 54e) or, in New York State, see the Cornell Pesticide Management Education Program website at <http://psep.cce.cornell.edu> (Link 54f).

10.3 Pollinator Protection

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

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

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

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

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

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

10.4 Optimizing Pesticide Effectiveness

Information on the effectiveness of a particular pesticide against a given pest can sometimes be difficult to find. Some university researchers include pesticides approved for organic production in their trials; some manufacturers provide trial results on their web sites; some farmers have conducted trials on their own. Efficacy ratings for pesticides listed in this guide were summarized from university trials and are only provided for some products. 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. Microbial-based products often have a shorter shelf life than other products, so be sure to use them by the expiration date. Read the pesticide label carefully to determine if water pH or hardness will negatively impact the pesticide's effectiveness. Use of a surfactant may improve organic pesticide performance. [OMRI lists adjuvants](#) on their website (Reference 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. The use of pheromone traps or other monitoring or prediction techniques can provide an early warning for pest problems, and help effectively focus scouting efforts. When using pesticides, be sure you have sufficient coverage to provide adequate control. Consult the pesticide label for guidance.

11. DISEASE MANAGEMENT

In organic systems, cultural practices form the basis of a disease management program. Promote plant health by maintaining a biologically active, well-structured, adequately drained and aerated soil that supplies the requisite amount and balance of nutrients. Choose varieties resistant to important diseases whenever possible (see Section 6: *Varieties*). Plant only clean, vigorous and pathogen-free seed 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 crop or crops that will be in place for one or more seasons, deprives many disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. 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, in western New York, the [Cornell Vegetable Program](#) offers subscriptions to *VegEdge*, a report that gives timely information regarding crop development, pest activity and control. Enrollment in the [Eastern New York Commercial Horticulture Program](#) includes a

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subscription to *Produce Pages* and weekly seasonal newsletters for vegetables, tree fruit, grapes and small fruit. On Long Island, see the *Long Island Fruit and Vegetable Update*.

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

Organic farms must comply with all other regulations regarding pesticide applications. See Section 10. Using

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


Table 11.0 Pesticides for Disease Control in Organic Spinach

CLASS OF COMPOUND Product name (Active ingredient)	Anthracnose	Damping Off	Downy Mildew	Leaf Spot	White Rust
MICROBIAL					
Actinovate AG (<i>Streptomyces lydicus</i> WYEC 108)	X	X	X		
BIO-TAM (<i>Trichoderma asperellum</i> , <i>Trichoderma gamsii</i>)		X			
BIO-TAM 2.0 (<i>Trichoderma asperellum</i> , <i>Trichoderma gamsii</i>)		X			
Double Nickel 55 Biofungicide (<i>Bacillus amyloliquefaciens</i> str. D747)		X	X	X	
Double Nickel LC Biofungicide (<i>Bacillus amyloliquefaciens</i> str. D747)		X	X	X	
MycoStop Biofungicide (<i>Streptomyces griseoviridis</i>)		X			
MycoStop Mix (<i>Streptomyces griseoviridis</i>)		X			
Prestop Biofungicide (<i>Gliocladium catenulatum</i> str. J1446)		X			
Regalia Biofungicide (<i>Reynoutria sachalinensis</i>)			X	X	X
RootShield WP (<i>Trichoderma harzianum</i> str. KRL_AG2)		X			
RootShield PLUS+ WP (<i>Trichoderma harzianum</i> str. T-22, <i>Trichoderma virens</i> str. G-41)		X			
RootShield Granules (<i>Trichoderma harzianum</i> str. T-22)		X			
RootShield PLUS+ Granules (<i>Trichoderma harzianum</i> str. T-22, <i>Trichoderma virens</i> str. G-41)		X			
Serenade ASO (<i>Bacillus subtilis</i>)			X		X
Serenade MAX (<i>Bacillus subtilis</i>)			X		X
Serenade Soil (<i>Bacillus subtilis</i>)		X			
SoilGard (<i>Gliocladium virens</i> str. GL-21)		X			
Taegro Biofungicide (<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> str. FZB24)		X			
Taegro ECO (<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> str. FZB24)		X	X		
Zonix (<i>Rhamnolipid Biosurfactant</i>)		X			
OILS					
Cinnerate (<i>cinnamon oil</i>)					X
Organocide 3-in-1 (<i>sesame oil</i>)			X		
Trilogy (<i>neem oil</i>)	X		X	X	X
COPPER					
Badge X2 (<i>copper oxychloride</i> , <i>copper hydroxide</i>)	X		X	X	X
Champ WG (<i>copper hydroxide</i>)	X		X	X	X
Champion++ (<i>copper hydroxide</i>)	X		X	X	X
Cueva Fungicide Concentrate (<i>copper octanoate</i>)			X	X	X
CS 2005 (<i>copper sulfate pentahydrate</i>)	X		X	X	X
Nordox 75 WG (<i>cuprous hydroxide</i>)	X		X	X	X

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Table 11.0 Pesticides for Disease Control in Organic Spinach

CLASS OF COMPOUND Product name (Active ingredient)	Anthracnose	Damping Off	Downy Mildew	Leaf Spot	White Rust
Nu-Cop 50 WP (copper hydroxide)	X		X	X	X
OTHER					
Acoidal (sulfur)					X
Agricure (potassium bicarbonate)	X		X		
Defend DF (sulfur)					X
Micro Sulf (sulfur)					X
Milstop (potassium bicarbonate)	X		X	X	
OxiDate 2.0 (hydrogen dioxide, peroxyacetic acid)			X		X
PERpose Plus (hydrogen peroxide/dioxide)	X	X	X	X	X
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)		X			

 Active ingredient meets EPA criteria for acute toxicity to bees

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 California [factsheet](#) (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 <i>Pythium</i> and <i>Rhizoctonia</i> 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.

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Management Option	Recommendation for Damping-off and Seed Rot
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.

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Table 11.1 Pesticides for Management of Damping-off and Seed Rot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (<i>Streptomyces lydicus</i> WYEC 108)	2-18 acre of seed seed treatment 3-12 oz/acre soil treatment	0	1 or until dry	?	Apply as a soil treatment at planting.
Actinovate STP (<i>Streptomyces lydicus</i>)	0.31-32 oz/ cwt seed seed treatment	0	1 or until dry	?	Apply as a dry coating, in planter box or in slurry.
BIO-TAM (<i>Trichoderma asperellum, Trichoderma gamsii</i>)	1.5-3 oz/1000 row feet in- furrow treatment 2.5-5 lb/acre	-	1	1	Trichoderma harzianum products effective in 1/1 trial.
BIO-TAM 2.0 (<i>Trichoderma asperellum, Trichoderma gamsii</i>)	2.5-5 lb/acre	-	4	1	See comment for BIO-TAM.
Double Nickel 55 (<i>Bacillus amyloliquefaciens</i> str D747)	0.125-1 lb/acre soil treatment	0	4	?	
Double Nickel LC (<i>Bacillus amyloliquefaciens</i> str D747)	0.5-4.5 pts/acre soil treatment	0	4	?	
MycoStop (<i>Streptomyces grievoviridis</i> str K61)	0.07 oz/ lb of seed seed treatment	-	4	?	
MycoStop (<i>Streptomyces grievoviridis</i> str K61)	15-30 oz/acre soil treatment	-	4	?	Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop into the root zone.
MycoStop Mix (<i>Streptomyces grievoviridis</i> str K61)	.05-.08 oz/ lb seed seed treatment 7.6-30 oz/acre soil treatment	-	4	?	Use at planting; no pre-harvest interval noted. Irrigate within 6 hours after soil spray or drench with enough water to move Mycostop into the root zone.
MycoStop Mix (<i>Streptomyces grievoviridis</i> str K61)	0.5-1 lb/ treated acre soil treatment	-	4	?	Band, in-furrow or side dress. Lightly incorporate furrow or band applications.
PERpose Plus (hydrogen peroxide)	1 fl oz/ gal soil drench	-	until dry	?	Apply to saturation.
Prestop (<i>Gliocladium</i>)	1.4-3.5 oz/ 2.5 gal water	-	0	?	Treat only growth substrate when above-

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Table 11.1 Pesticides for Management of Damping-off and Seed Rot					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
<i>catenulatum</i>)	soil drench				ground harvestable food commodities are present.
RootShield Granules (<i>Trichoderma harzianum</i>)	2.5-6 half acre in-furrow treatment	-	0	1	Trichoderma harzianum products effective in 1/1 trial.
RootShield PLUS+ Granules (<i>Trichoderma harzianum</i> , <i>Trichoderma virens</i>)	2.5-6 half acre in-furrow treatment	-	0	1	Trichoderma harzianum products effective in 1/1 trial.
RootShield PLUS+ WP (<i>Trichoderma harzianum</i> , <i>Trichoderma virens</i>)	16-32 oz/acre in-furrow treatment	0	4	1	Trichoderma harzianum products effective in 1/1 trial. Do not apply when above-ground harvestable food commodities are present.
RootShield WP (<i>Trichoderma harzianum</i>)	16-32 oz/acre in-furrow treatment	-	until dry	1	Trichoderma harzianum products effective in 1/1 trial.
Serenade Soil ¹ (<i>Bacillus subtilis</i> str QST 713)	2-6 qt/acre soil drench	0	4	?	Labeled for Rhizoctonia only.
Soilgard (<i>Gliocladium virens</i>)	2-10 lb/acre in-furrow treatment	-	0	?	Applied as a banded drench in-furrow at or immediately before planting.
Taegro (<i>Bacillus subtilis</i>)	3 tsp/gal seed treatment	-	24	?	Labeled for Rhizoctonia only.
Taegro (<i>Bacillus subtilis</i>)	2.6 oz/100 gal water in- furrow treatment	-	24	?	Labeled for Rhizoctonia only. Soil drench or over furrow at time of planting.
Taegro ECO (<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> str. FZB2)	2.6-5.2 oz/acre soil drench	-	24	?	Labeled for Rhizoctonia only. Apply at planting or immediately following planting as a soil spray (in-furrow).
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water soil treatment	up to day	0	?	Soil treatment prior to seeding or transplanting. Applied at 26-100 gallons of finished solution per acre-row.
TerraClean 5.0 (hydrogen dioxide, peroxyacetic acid)	25 fl oz/ 200 gal water /1000 sq ft soil drench	up to day	0	?	Soil drench with established plants or seedlings.
Zonix (Rhamnolipid Biosurfactant)	0.5-0.8 oz/ gal soil treatment	-	4	?	Labeled for Pythium only. Contact biofungicide. Thorough coverage is necessary for disease control.

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. ¹Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest

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

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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 [fact sheet](#) (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: <i>Varieties</i>).
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.

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Table 11.2 Pesticides for Management of Downy Mildew					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (<i>Streptomyces lydicus</i> WYEC 108)	3-12 oz/acre	0	1 or until dry	?	The label recommends using a spreader sticker for foliar applications.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Badge X2 (copper hydroxide, copper oxychloride)	0.75-1.25 lb/acre	0	48	3	Copper products have shown poor results in trials. Flecking may occur on spinach leaves.
Champ WG (copper hydroxide)	1-1.58 lb/acre	-	48	3	Repeat every 7-10 days or as needed. Copper products have shown poor results in trials. Flecking may occur on spinach leaves.
Champion++ (copper hydroxide)	0.75-1.25 lb/acre	0	48	?	
Cueva Fungicide Concentrate (copper octanoate)	0.5-2 gal/acre	up to day	4	3	Copper products have shown poor results in trials.

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Table 11.2 Pesticides for Management of Downy Mildew					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Double Nickel 55 (<i>Bacillus amyloliquefaciens</i> str D747)	0.25-3 lb/acre	0	4	?	Repeat every 7-10 days or as needed.
Double Nickel LC (<i>Bacillus amyloliquefaciens</i> str D747)	0.5-6 qt/acre	0	4	?	
Milstop (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Nordox 75 WG (cuprous oxide)	1.25-2 lb/acre	-	12	3	Repeat every 7-10 days or as needed. Copper products have shown poor results in trials.
Nu-Cop 50 WP (copper hydroxide)	2-4 lb/acre	1	24	3	Repeat every 7-10 days or as needed. Copper products have shown poor results in trials.
Oxidate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl oz/100 gal water curative 32 fl oz/100 gal water preventative	0	until dry	?	Apply 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. Bee hazard. This product is toxic to bees exposed to direct contact.
PERpose Plus (hydrogen peroxide)	1 fl oz/gal (initial/curative)	-	until dry	?	For initial or curative use, apply initial/curative rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.
PERpose Plus (hydrogen peroxide)	0.25-0.33 fl oz/ gal (weekly/preventative)	-	until dry	?	For weekly or preventative treatments, apply weekly/preventative rate every five to seven days. At first signs of disease, use curative rate for 3 consecutive days then resume weekly preventative treatment.
Regalia (<i>Reynoutria sachalinensis</i>)	0.5-4 qt/acre	0	4	?	Repeat every 7-14 days.
Serenade ASO ¹ (<i>Bacillus subtilis</i> str QST 713)	2-6 qt/acre	0	4	?	Repeat on 2-10 day intervals as needed.
Serenade MAX ¹ (<i>Bacillus subtilis</i> str QST 713)	1-3 lb/acre	0	4	?	Repeat on 2-10 day intervals as needed.
Taegro ECO (<i>Bacillus subtilis</i> var. amyloliquefaciens str FZB2)	2.6-5.2 oz/acre	-	24	?	Addition of a non-ionic surfactant may improve disease control.


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Table 11.2 Pesticides for Management of Downy Mildew

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Trilogy (neem oil)	0.5-1% solution	up to day	4	?	Maximum labeled use of 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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

PHI = pre-harvest interval, REI = restricted-entry interval. - = pre-harvest interval isn't specified on label. ¹Serenade Opti and Serenade ASO (labeled for foliar and soil uses) will be the only formulations in the future. Formulations may differ in efficacy, especially older and newer ones. ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest

 Active ingredient meets EPA criteria for acute toxicity to bees

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: <i>Varieties</i>).
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 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, <i>Chenopodium capitatum</i> (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.

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Table 11.3 Pesticides for Management of White Rust					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Acoidal (sulfur)	4-6 lb/acre	-	24	?	
Badge X2 (copper hydroxide, copper oxychloride)	0.75-1.25 lb/acre	0	48	1	Flecking may occur on spinach leaves. Copper products effective in 1/1 trial.
Champ WG (copper hydroxide)	1-1.58 lb/acre	-	48	1	Repeat every 7-10 days or as needed. Flecking may occur on spinach leaves. Copper products effective in 1/1 trial.
Champion++ (copper hydroxide)	0.75-1.25 lb/acre	0	48	?	
Cinnerate (cinnamon oil)	13-30 fl oz/100 gal water	-	-	?	25(b) pesticide.
CS 2005 (copper sulfate pentahydrate)	19.2-25.6 oz/acre	0	48	1	Flecking may occur on spinach leaves. Copper products effective in 1/1 trial.
Cueva Fungicide Concentrate (copper octanoate)	0.5-2 gal/acre	up to day	4	1	Copper products effective in 1/1 trial.
Defend DF (sulfur)	4-6 lb/acre	-	24	?	
Micro Sulf (sulfur)	4-6 lb/acre	-	24	?	
Nordox 75 WG (cuprous oxide)	1.25-2 lb/acre	-	12	1	Repeat every 7-10 days or as needed. Copper products effective in 1/1 trial.
Nu-Cop 50 WP (copper hydroxide)	2-4 lb/acre	1	24	1	Flecking may occur on spinach leaves. Copper products effective in 1/1 trial.
Oximate 2.0 (hydrogen dioxide, peroxyacetic acid)	128 fl.oz./100 gal water Curative	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. Bee Hazard. This product is toxic to bees exposed to direct contact.
Oximate 2.0 (hydrogen dioxide, peroxyacetic acid)	32 fl.oz./100 gal water Preventative	0	until dry	?	Apply 30-100 gals spray solution per treated acre. Bee Hazard. This product is toxic to bees exposed to direct contact.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal (initial/curative)	-	until dry	?	For initial or curative use, apply initial/curative rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.

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Table 11.3 Pesticides for Management of White Rust					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
PERpose Plus (hydrogen peroxide)	0.25-0.33 fl.oz./ gal (weekly/preventative)	-	until dry	?	For weekly or preventative treatments, apply weekly/preventative rate every five to seven days. At first signs of disease, use curative rate for 3 consecutive days then resume weekly preventative treatment.
Regalia (<i>Reynoutria sachalinensis</i>)	0.5-4 qt/acre	0	4	?	
Serenade ASO ¹ (<i>Bacillus subtilis</i> str QST 713)	2-6 qt/acre	0	4	?	Repeat on 2-10 day intervals as needed.
Serenade MAX ¹ (<i>Bacillus subtilis</i> str QST 713)	1-3 lb/acre	0	4	?	Repeat on 2-10 day intervals as needed.
Trilogy (neem oil)	0.5-1% solution	Up to day	4	?	Maximum labeled use of 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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

☞ Active ingredient meets EPA criteria for acute toxicity to bees

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 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°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.

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Management Option	Recommendation for Cucumber Mosaic Virus
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 for Management of Anthracnose					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Actinovate AG (<i>Streptomyces lydicus</i> WYEC 108)	3-12 oz/acre	0	1 or until dry	?	The label recommends using a spreader sticker for foliar applications.
Agricure (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Badge X2 (copper hydroxide, copper)	0.75-1.25 lb/acre	0	48	?	Flecking may occur on spinach leaves.

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oxychloride)					
Champ WG (copper hydroxide)	1-1.58 lb/acre	-	48	?	Repeat every 7-10 days or as needed. Flecking may occur on spinach leaves.
Champion++ (copper hydroxide)	0.75-1.25 lb/acre	0	48	?	
CS 2005 (copper sulfate pentahydrate)	19.2-25.6 oz/acre	0	48	?	Flecking may occur on spinach leaves.
Milstop (potassium bicarbonate)	2-5 lb/acre	0	1	?	
Nordox 75 WG (cuprous oxide)	1.25-2 lb/acre	-	12	?	Repeat every 7-10 days or as needed.
Nu-Cop 50 WP (copper hydroxide)	2-4 lb/acre	1	24	?	Repeat every 7-10 days or as needed. Flecking may occur on spinach leaves.
PERpose Plus (hydrogen peroxide)	1 fl.oz./ gal (initial/curative)	-	until dry	?	For initial or curative use, apply initial/curative rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.
PERpose Plus (hydrogen peroxide)	0.33 fl.oz./ gal (weekly/preventative)	-	until dry	?	For weekly or preventative treatments, apply preventative rate every five to seven days. At first signs of disease, use curative rate for 3 consecutive days then resume weekly preventative treatment.
Trilogy (neem oil)	0.5-1% solution	up to day	4	?	Maximum labeled use of 2gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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

 Active ingredient meets EPA criteria for acute toxicity to bees

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 lose 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).

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

Table 11.6 Pesticides for Management of Leaf Spot					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Badge X2 (copper hydroxide, copper oxychloride)	0.75-1.25 lb/acre	0	48	?	Flecking may occur on spinach leaves. Labeled for Cercospora leaf spot only.
Champ WG (copper hydroxide)	1-1.58 lb/acre	-	48	?	Repeat every 7-10 days or as needed. Flecking may occur on spinach leaves. Labeled for Cercospora leaf spot only.
Champion++ (copper hydroxide)	0.75-1.25 lb/acre	0	48	?	Labeled for Cercospora leaf spot only.
CS 2005 (copper sulfate pentahydrate)	19.2-25.6 oz/acre	0	48	?	Flecking may occur on spinach leaves. Labeled for Cercospora leaf spot only.
Cueva Fungicide Concentrate (copper octanoate)	0.5-2 gal/acre	up to day	4	?	Labeled for Cercospora leaf spot only.
Double Nickel 55 (Bacillus amyloliquifaciens strain D747)	0.25-3 lb/acre	0	4	?	Repeat every 7-10 days or as needed. Labeled for Cercospora leaf spot only.
Double Nickel LC (Bacillus amyloliquifaciens strain D747)	0.5-6 qt/acre	0	4	?	Labeled for Cercospora leaf spot only.
Milstop (Potassium bicarbonate)	2-5 lb/acre	0	1	?	.Labeled for Cercospora leaf spot only.
Nordox 75 WG (cuprous oxide)	1.25-2 lb/acre	-	12	?	Repeat every 7-10 days or as needed. Labeled for Cercospora leaf spot only.
Nu-Cop 50 WP (copper hydroxide)	2-4 lb/acre	1	24	?	Repeat every 7-10 days or as needed. Labeled for Cercospora leaf spot only.
PERpose Plus (hydrogen peroxide)	1 fl oz/ gal (initial/curative)	-	until dry	?	For initial or curative use, apply initial/curative rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.
PERpose Plus (hydrogen peroxide)	0.25-0.33 fl oz/ gal (weekly/preventative)	-	until dry	?	For weekly or preventative treatments, apply weekly/preventative rate every five to seven days. At first signs of disease, use curative rate for 3 consecutive days then resume weekly preventative treatment.
Regalia (<i>Reynoutria sachalinensis</i>)	0.5-4 qt/acre	0	4	?	Labeled for Cercospora leaf spot only.

Table 11.6 Pesticides for Management of Leaf Spot

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Trilogy (neem oil)	0.5-1% solution	up to day	4	?	Maximum labeled use of 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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

 Active ingredient meets EPA criteria for acute toxicity to bees

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.

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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).

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

Table 13. Pesticides for Insect Control in Organic Spinach				
CLASS OF COMPOUND				
Product name (Active ingredient)	Green Peach Aphid	Leafminer	Cabbage Looper	Flea Beetle
MICROBIAL				
Agree WG (<i>Bacillus thuringiensis aizawai</i> str. GC-91)			X	
Biobit HP (<i>Bacillus thuringiensis subsp. kurstaki</i> , str. ABTS-351)			X	
Deliver (<i>Bacillus thuringiensis kurstaki</i>)			X	
DiPel DF (<i>Bacillus thuringiensis kurstaki</i>)			X	
Entrust (☞ <i>spinosad</i>)		X	X	
Entrust SC (☞ <i>spinosad</i>)		X	X	
Grandevo (<i>Chromobacterium subtsugae</i> str. PRAA4-1)	X		X	
Javelin WG (<i>Bacillus thuringiensis kurstaki</i>)			X	
PFR-97 20% WDG (<i>Isaria fumosorosea</i> Apopka str. 97)	X			
XenTari (<i>Bacillus thuringiensis aizawai</i>)			X	
BOTANICAL				
Aza-Direct (☞ <i>azadirachtin</i>)	X	X	X	X
Azaguard (☞ <i>azadirachtin</i>)	X	X	X	X
AzaMax (☞ <i>azadirachtin</i>)	X	X	X	X
AzaSol (☞ <i>azadirachtin</i>)	X	X	X	X
Azatrol EC (☞ <i>azadirachtin</i>)	X	X	X	X
BioLink (garlic juice)	X	X	X	X
BioLink Insect & Bird Repellant (garlic juice)	X	X	X	X
Ecozin Plus (☞ <i>azadirachtin</i>)	X	X	X	X
Envirepel 20 (garlic juice)	X	X	X	
Garlic Barrier AG (garlic juice)	X	X	X	
Molt-X (☞ <i>azadirachtin</i>)	X	X	X	X
Neemix 4.5 (☞ <i>azadirachtin</i>)	X	X	X	X
PyGanic EC 1.4 _{II} (☞ <i>pyrethrin</i>)	X	X	X	X
PyGanic EC 5.0 _{II} (☞ <i>pyrethrin</i>)	X	X	X	X

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Table 13. Pesticides for Insect Control in Organic Spinach				
CLASS OF COMPOUND				
Product name (Active ingredient)	Green Peach Aphid	Leafminer	Cabbage Looper	Flea Beetle
Surround WP (kaolin)				X
Trilogy (neem oil)	X			
OILS				
BioRepel (garlic oil)	X			
Cedar Gard (cedar oil)		X		X
Ecotec (rosemary and peppermint oil)	X		X	X
GC-Mite (cottonseed, clove and garlic oils)	X			
GrasRoots (cinnamon oil)	X			
Oleotrol-I (soybean oil)	X			
Organocide (sesame oil)	X			
OTHER				
Azera (azadirachtin and pyrethrins)	X	X	X	X
DES-X (insecticidal soap)	X			
M-Pede (potassium salts of fatty acids)	X	X		
Nuke Em (citric acid)	X			
Sil-Matrix (potassium silicate)	X			

Active ingredient meets EPA criteria for acute toxicity to bees

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	<p>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.</p> <p>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.</p>

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

Table 13.1 Pesticides for Management of Green Peach Aphid					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Azadirachtin based products effective in 4/7 trials.
AzaGuard (azadirachtin)	10-16 fl oz/acre	0	Until Dry	1	See comment for Aza-Direct. Apply with OMRI approved spray oil.
AzaMax (azadirachtin)	1.33 fl oz/ 1000 sq ft	0	4	1	See comment for Aza-Direct.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for Aza-Direct. Foliar spray or drench.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/ 1000 sq ft	0	4	1	See comment for Aza-Direct.
Azera (azadirachtin, pyrethrins)	32 fl.oz./acre	-	12	1	See comment for Aza-Direct.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellant.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellant.
BioRepel (garlic oil)	1 part BioRepel with 100 parts water	-	-	?	25(b) pesticide. Repellant.
DES-X (insecticidal soap)	2% solution	1/2	12	?	
Ecotec (rosemary oil, peppermint oil)	1-4 pts/100 gal water	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME	15-30 oz/acre	0	4	1	See comment for Aza-Direct. Will not control

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Table 13.1 Pesticides for Management of Green Peach Aphid					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI²(Days)	REI (Hours)	Efficacy	Comments
(azadirachtin)					adults.
Envirepel 20 (garlic juice)	10-32 oz/acre	-	-	?	25(b) pesticide. Repellant.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide. Repellant.
GC-Mite (garlic oil, clove oil, cottonseed oil)	1 gal/100 gal water	-	-	?	25(b) pesticide
Grandevo (<i>Chromobacterium subtsugae</i> str. PRAA4-1)	2-3 lb/acre	0	4	?	
GrasRoots (cinnamon oil)	1 part GrasRoots to 9 parts water	-	-	?	25(b) pesticide.
Molt-X (azadirachtin)	10 oz/acre	0	4	1	See comment for Aza-Direct. Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves.
M-Pede (insecticidal soap)	1-2% volume to volume	0	12	3	Soap based products not effective in 9/9 trials. Must be tank mixed with another labeled companion insecticide.
Neemix 4.5 (azadirachtin)	5-7 fl oz/acre	0	4	1	See comment for Aza-Direct. Suppression and adult feeding deterrence.
Nuke Em Natural Insecticide and Fungicide (citric acid)	1 fl oz/ 31 fl oz water to 2 fl oz/30 fl oz water	-	-	?	25(b) pesticide.
Oleotrol-I Bio-Insecticide Concentrate (soybean oil)	1 part Oleotrol-I with 300 parts water	-	-	?	25(b) pesticide
PFR-97 20% WDG (Isaria fumosorosea Apopka str. 97)	1-2 lb/acre	-	4	?	Repeat applications at 3-10 day intervals as needed to maintain control.
PyGanic EC 1.4 II (pyrethrins)	16-64 fl.oz./acre	until dry	12	2	Pyrethrin based products effective in 1/3 trials.
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl.oz./acre	until dry	12	2	Pyrethrin based products effective in 1/3 trials.
Sil-Matrix (potassium silicate)	2-4 qt/100 gal water	0	4	?	
Trilogy (neem oil)	1-2% solution	Up to day	4	?	Maximum labeled use of 2 gal/acre/application. Bee Hazard. This product is toxic to bees exposed to direct contact.

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

Active ingredient meets EPA criteria for acute toxicity to bees

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

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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	<p>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 mines are most obvious. Look for mines and newly hatching larvae.</p> <p>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.</p>
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	<p>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).</p> <p>Pick and destroy leaves with mining damage before the larvae emerge to limit future generations.</p>
Chemical controls	Initiate treatment when thresholds are reached.

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Table 13.2 Pesticides for Management of Spinach Leafminer


Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops. Foliar spray or drench.
AzaGuard (azadirachtin)	10-16 gal/acre	0	until dry	3	Apply with OMRI approved spray oil. Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops. Foliar spray or drench.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops.
AzaSol (azadirachtin)	6 oz/acre	-	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops. Foliar spray or drench.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/ 1000 sq ft	0	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellant.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellant.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops. Foliar spray or drench.
Entrust (spinosad)	2-3 oz/acre	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./acre	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.
Envirepel 20 (garlic juice)	10-32 oz/acre	-	-	?	25(b) pesticide. Repellant.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide. Repellant.
Molt-X (azadirachtin)	10 oz/acre	0	4	3	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves. Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops.
M-Pede (insecticidal soap)	1-2% volume to volume	0	12	?	Must be tank mixed with another labeled companion insecticide.
Neemix 4.5 (azadirachtin)	4-7 fl.oz./acre	0	4	3	Azadirachtin based products effective in 0/2 trials against leafminers on vegetable crops.

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Table 13.2 Pesticides for Management of Spinach Leafminer

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
PyGanic EC 1.4 II (pyrethrins)	16-64 fl.oz./acre	until dry	12	?	
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl.oz./acre	until dry	12	?	

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

 Active ingredient meets EPA criteria for acute toxicity to bees

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 1/2 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.
Traps	Bucket-type pheromone (or UV light traps) traps can be used to monitor moth flight. See Pheromone traps for insect pest management (Reference 80) 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.

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Management Option	Recommendation for Cabbage Looper
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.

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

Table 13.3 Pesticides for Management of Cabbage Looper					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI ² (Days)	REI (Hours)	Efficacy	Comments
Agree WG (<i>Bacillus thuringiensis</i>)	0.5-2 lb/acre	up to day	4	1	Bt products effective in 6/7 trials. Good coverage is essential.
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	1	Azadirachtin-based products effective in 2/4 trials.
AzaGuard (azadirachtin)	8-16 gal/acre	0	until dry	1	Apply with OMRI approved spray oil. See comment for Aza-direct.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	1	See comment for Aza-direct.
AzaSol (azadirachtin)	6 oz/acre	-	4	1	See comment for Aza-direct.
Azatrol-EC (azadirachtin)	0.19-0.96 fl oz/1000 sq ft	0	4	1	See comment for Aza-direct.
Azera (azadirachtin, pyrethrins)	32 fl oz/acre	-	12	1	
Biobit HP (<i>Bacillus thuringiensis</i> subsp. kurstaki)	0.5-1 lb/acre	0	4	1	Bt products effective in 6/7 trials. Good coverage is essential.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellant.
BioLink Insect & Bird Repellant (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellant.
Deliver (<i>Bacillus thuringiensis</i> subsp. kurstaki)	0.25-1.5 lb/acre	0	4	1	Bt products effective in 6/7 trials.
Dipel DF (<i>Bacillus thuringiensis</i> subsp. kurstaki)	0.5-2 lb/acre	0	4	1	See comment for Deliver.
Ecotec (rosemary oil, peppermint oil)	1-4 pts/100 gal water	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	1	See comment for Aza-direct.
Entrust (spinosad)	1-2 oz/acre	1	4	1	Effective in 41/47 trials against caterpillars including cabbage looper. May provide incidental control of flea beetles when applied for loopers.

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Table 13.3 Pesticides for Management of Cabbage Looper					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI² (Days)	REI (Hours)	Efficacy	Comments
Entrust SC (☞spinosad)	3-6 fl oz /acre	1	4	1	See comment for Entrust. May also provide incidental control of spinach flea beetle.
Envirepel 20 (garlic juice)	10-32 oz/acre	-	-	?	25(b) pesticide. Repellant.
Garlic Barrier AG (garlic juice)	1-2% solution	-	-	?	25(b) pesticide. Repellant.
Grandevo (<i>Chromobacterium subtsugae</i> str. PRAA4-1)	1-3 lb/acre	0	4	?	
Javelin WG (<i>Bacillus thuringiensis</i> subsp. kurstaki)	0.12-1.5 pt/acre	0	4	1	See comment for Deliver.
Molt-X (☞azadirachtin)	8 oz/acre	0	4	1	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves. See comment for Aza-direct.
Neemix 4.5 (☞azadirachtin)	7-16 fl oz/acre	0	4	1	See comment for Aza-direct.
PyGanic EC 1.4 II (☞pyrethrins)	16-64 fl oz/acre	until dry	12	1	Pyrethrum products effective in 1/1 trial.
PyGanic EC 5.0 II (☞pyrethrins)	4.5-17 fl oz/acre	until dry	12	1	Pyrethrum products effective in 1/1 trial.
XenTari (<i>Bacillus thuringiensis</i> , var. aizawai)	0.5-1.5 lb/acre	0	4	1	See comment for Deliver.

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

☞ Active ingredient meets EPA criteria for acute toxicity to bees

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.

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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.

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

Table 13.4 Pesticides for Management of Spinach Flea Beetle

Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI (Days)	REI (Hours)	Efficacy	Comments
Aza-Direct (azadirachtin)	1-2 pts/acre	0	4	2	Foliar spray or drench. Azadirachtin based products effective in 1/3 trials. Larvicide; may suppress adult feeding.
AzaGuard (azadirachtin)	8-16 gal/acre	0	until dry	2	Apply with OMRI approved spray oil. Foliar spray or drench. Azadirachtin based products effective in 1/3 trials.
AzaMax (azadirachtin)	1.33 fl oz/1000 sq ft	0	4	2	Azadirachtin based products effective in 1/3 trials.
AzaSol (azadirachtin)	6 oz/acre	-	4	2	See comment for AzaMax.
Azatrol-EC (azadirachtin)	0.24-0.96 fl oz/1000 sq ft	0	4	2	See comment for AzaMax.
Azera (azadirachtin, pyrethrins)	32 fl oz/acre	-	12	2	See comment for AzaMax.
BioLink (garlic juice)	0.5-2 qt/acre	-	-	?	25(b) pesticide. Repellent.
BioLink Insect & Bird Repellent (garlic juice)	0.5-4 qt/acre	-	-	?	25(b) pesticide. Repellent.
Cedar Gard (cedar oil)	1 qt/acre	-	-	?	25(b) pesticide
Ecotec (Rosemary oil, Peppermint oil)	1-4 pts/100 gal water	-	-	?	25(b) pesticide
Ecozin Plus 1.2% ME (azadirachtin)	15-30 oz/acre	0	4	2	See comment for AzaMax. Larvicide; may suppress adult feeding.
Molt-X (azadirachtin)	8 oz/acre	0	4	2	Use in combination with 0.25 -1% organic non-phytotoxic crop oil in sufficient water to cover undersides of leaves. Azadirachtin based products effective in 1/3 trials.

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Table 13.4 Pesticides for Management of Spinach Flea Beetle					
Class of Compounds Product Name (Active Ingredient)	Product Rate	PHI (Days)	REI (Hours)	Efficacy	Comments
Neemix 4.5 (azadirachtin)	7-16 fl oz /acre	0	4	2	See comment for Ecozin Plus
PyGanic EC 1.4 II (pyrethrins)	16-64 fl oz /acre	until dry	12	2	
PyGanic EC 5.0 II (pyrethrins)	4.5-17 fl oz/acre	until dry	12	2	
Surround WP (kaolin clay)	25-50 lb/acre	Up to day	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. ²Note that when the REI is longer than the PHI, Worker Protection Standard requirements may necessitate waiting until after REI to harvest.

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14. PESTICIDES AND ABBREVIATIONS MENTIONED IN THIS PUBLICATION

Table 14.1 Insecticides and molluscides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Agree WG	<i>Bacillus thuringiensis aizawai str. GC-91</i>	70051-47
Aza-Direct	azadirachtin	71908-1-10163
AzaGuard	azadirachtin	70299-17
AzaMax	azadirachtin	71908-1-81268
AzaSol	azadirachtin	81899-4
Azatrol EC	azadirachtin	2217-836
Azera	azadirachtin and pyrethrins	1021-1872
Biobit HP	<i>Bacillus thuringiensis subsp. kurstaki, str. ABTS-351</i>	73049-54
BioLink	garlic juice	Exempt 25(b) pesticide
BioLink Insect & Bird Repellent	garlic juice	Exempt 25(b) pesticide
BioRepel	garlic oil	Exempt 25(b) pesticide
Cedar Gard	cedar oil	Exempt 25(b) pesticide
Deliver	<i>Bacillus thuringiensis kurstaki</i>	70051-69
DES-X	insecticidal soap	67702-22-70051
DiPel DF	<i>Bacillus thuringiensis kurstaki</i>	73049-39
Ecotec	rosemary and peppermint oil	Exempt 25(b) pesticide
Ecozin Plus	azadirachtin	5481-559
Entrust	spinosad	62719-282
Entrust SC	spinosad	62719-621
Envirepel 20	garlic juice	Exempt 25(b) pesticide
Garlic Barrier AG+	garlic juice	Exempt 25(b) pesticide
GC-Mite	cottonseed, clove, and garlic oils	Exempt 25(b) pesticide
Grandevo	<i>Chromobacterium subsugae str. PRAA4-1</i>	84059-17
Grasroots	cinnamon oil	Exempt 25(b) pesticide
Javelin WG	<i>Bacillus thuringiensis kurstaki</i>	70051-66
Molt-X	azadirachtin	68539-11
M-Pede	potassium salts of fatty acids	10163-324
Neemix 4.5	azadirachtin	70051-9
Nuke Em	citric acid	Exempt 25(b) pesticide
Oleotrol-I	soybean oil	Exempt 25(b) pesticide
Organocide 3-in-1	sesame oil	Exempt 25(b) pesticide
PFR-97 20% WDG	<i>Isaria fumosorosea Apopka str. 97</i>	70051-19
PyGanic Crop Protection EC 1.4 II	pyrethrin	1021-1771

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Table 14.1 Insecticides and molluscides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
PyGanic Crop Protection EC 5.0 II	pyrethrin	1021-1772
Sil-Matrix	potassium silicate	82100-1
Surround WP	kaolin	61842-18
Trilogy	neem oil	70051-2
XenTari	<i>Bacillus thuringiensis aizawai</i>	73049-40

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Table 14.2 Fungicides mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
Acoidal	sulfur	62562-4
Actinovate AG	<i>Streptomyces lydicus</i> WYEC 108	73314-1
Agricure	potassium bicarbonate	70870-1
Badge X2	copper oxychloride, copper hydroxide	80289-12
BIO-TAM	<i>Trichoderma asperellum</i> , <i>Trichoderma gamsii</i>	80289-9-69592
BIO-TAM 2.0	<i>Trichoderma asperellum</i> , <i>Trichoderma gamsii</i>	80289-9
Champ WG	copper hydroxide	55146-1
ChamplON++	copper hydroxide	55146-115
Cinnerate	cinnamon oil	Exempt 25(b) pesticide
CS 2005	copper sulfate pentahydrate	66675-3
Cueva Fungicide Concentrate	copper octanoate	67702-2-70051
Defend DF	sulfur	62562-8
Double Nickel 55 Biofungicide	<i>Bacillus amyloliquefaciens</i> str. D747	70051-108
Double Nickel LC Biofungicide	<i>Bacillus amyloliquefaciens</i> str. D747	70051-107
Micro Sulf	sulfur	55146-75
Milstop	potassium bicarbonate	70870-1-68539
Mycostop Biofungicide	<i>Streptomyces griseoviridis</i> str. K61	64137-5
MycoStop Mix	<i>Streptomyces griseoviridis</i> str. K61	64137-9
Nordox 75 WG	cuprous hydroxide	48142-4
Nu-Cop 50 WP	cupric hydroxide	45002-7
Nu-Cop HB	cupric hydroxide	42750-132
Organocide 3-in-1	sesame oil	Exempt 25(b) pesticide
OxiDate 2.0	hydrogen dioxide/peroxyacetic acid	70299-12
PERpose Plus	hydrogen peroxide/dioxide	86729-1
Prestop Biofungicide	<i>Gliocladium catenulatum</i> str. J1446	64137-11
Regalia Biofungicide	<i>Reynoutria sachalinensis</i>	84059-3
RootShield WP	<i>Trichoderma harzianum</i> str. KRL_AG2	68539-7
RootShield PLUS+ WP	<i>Trichoderma harzianum</i> str. T-22, <i>Trichoderma virens</i> str. G-41	68539-9
RootShield Granules	<i>Trichoderma harzianum</i> str. T-22	68539-3
RootShield PLUS+ Granules	<i>Trichoderma harzianum</i> str. T-22, <i>Trichoderma virens</i> str. G-41	68539-10
Serenade ASO	<i>Bacillus subtilis</i>	69592-12 and 264-1152
Serenade MAX	<i>Bacillus subtilis</i>	69592-11 and 264-1151
Serenade Soil	<i>Bacillus subtilis</i>	69592-12 and 264-1152
SoilGard	<i>Gliocladium virens</i> str. GL-21	70051-3
Taegro Biofungicide	<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> str. FZB24	70127-5
Taegro ECO	<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> str. FZB24	70127-5-100
TerraClean 5.0	hydrogen dioxide, peroxyacetic acid	70299-13
Trilogy	neem oil	70051-2
Zonix	Rhamnolipid Biosurfactant	72431-1

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Table 14.3 Sanitizers mentioned in this publication

TRADE NAME	ACTIVE INGREDIENT	EPA REG. NO.
CDG Solution 3000	<i>chlorine dioxide</i>	75757-2
Enviroguard Sanitizer	<i>hydrogen peroxide/ peroxyacetic acid</i>	63838-1-527
Oxine	<i>chlorine dioxide</i>	9804-1
Oxonia Active	<i>hydrogen peroxide/ peroxyacetic acid</i>	1677-129
Peraclean 5	<i>hydrogen peroxide/ peroxyacetic acid</i>	54289-3
Peraclean 15	<i>hydrogen peroxide/ peroxyacetic acid</i>	54289-4
Perasan 'A'	<i>peroxy acetic acid/ hydrogen peroxide</i>	63838-1
Per-Ox	<i>peroxy acetic acid/ hydrogen peroxide</i>	833-4
Pro Oxine	<i>chlorine dioxide</i>	9804-9
SaniDate 5.0	<i>hydrogen peroxide/ peroxyacetic acid</i>	70299-19
SaniDate 12.0	<i>hydrogen peroxide/ peroxyacetic acid</i>	70299-18
San-I-King No. 451	<i>sodium hypochlorite</i>	2686-20001
Shield-Brite PAA 5.0	<i>peroxy acetic acid/ hydrogen peroxide</i>	70299-19-64864
Shield-Brite PAA 12.0	<i>hydrogen peroxide/ peroxyacetic acid</i>	70299-18-64864
StorOx 2.0	<i>hydrogen peroxide/ peroxyacetic acid</i>	70299-7
Tsunami 100	<i>hydrogen peroxide/ peroxyacetic acid</i>	1677-164
Victory	<i>hydrogen peroxide/ peroxyacetic acid</i>	1677-186
VigorOx 15 F & V	<i>hydrogen peroxide/ peroxyacetic acid</i>	65402-3
VigorOx LS-15	<i>hydrogen peroxide/ peroxyacetic acid</i>	65402-3

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 ₂ O	potassium oxide	WPS	Worker Protection Standard
		*	Restricted-use Pesticide

15. REFERENCES

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