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Production Guide for Organic Strawberries

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2010 Production Guide for
Organic Strawberries

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INTRODUCTION

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

Strawberries are moderately amenable to organic production. The greatest challenge, by far, is weeds, particularly in the planting year. Studies have shown that sustained weed pressure in the planting year can negatively affect yield for several subsequent years. It is also difficult to provide a large amount of nitrate nitrogen when the strawberry plant needs it most: early spring and late fall. There are also a few pests that can be impossible to control organically if the weather does not cooperate (e.g. gray mold on fruit). But, with sufficient attention to weed management, especially in the planting year, and with good soil nitrogen reserves, strawberries can be successfully grown with organic production methods.

Organic strawberry production systems generally share five common characteristics, described in the Strawberry Production Guide for the Northeast, Midwest, and Eastern Canada, NRAES-88:

1. Several years elapse between successive strawberry crops. That is, practice 3- to 5-year-long crop rotations.
2. The production cycle is short, only one or two fruiting years, to avoid the establishment of perennial weeds and depletion of nitrogen reserves.
3. The labor requirements are high because of the need for hand-weeding and frequent light cultivation.
4. Yields tend to be lower in older plantings because weeds and pests tend to build up over time.
5. There is variability in yield due to weather and variable pest pressure.

For a more comprehensive understanding of strawberry production we suggest the following resources: Strawberry Production Guide for the Northeast, Midwest, and Eastern Canada, NRAES-88 available for purchase from: www.nraes.org/, and Strawberries: Organic Production, available on line at: http://attra.ncat.org/attra-pub/strawberry.html.

More research on growing perennial crops organically is needed, especially in the area of pest management. This guide attempts to compile the most current information available, but acknowledges that effective means of organic control are not available for some pests. Future revisions to this guide 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 has an affinity to organic production in its emphasis on the use of cultural practices to minimize pest outbreaks. With the limited pest control products available in many organic production systems, IPM techniques, such as keeping accurate pest history records, selecting the proper site, and preventing pest outbreaks through use of sanitation, variety selection and biological controls, are essential to producing a high quality crop.

All website addresses and links are listed in section 10. References. A glossary of terms used in this guide is included at the end in section 11.

1. GENERAL ORGANIC MANAGEMENT PRACTICES

1.1 Organic Certification

Who needs to be certified?

Operations or portions of operations that produce or handle agricultural products that are intended to be sold, labeled, or represented as "100 percent organic," "organic," or "made with organic ingredients" or food group(s).

Farming operations that gross more than $5,000 per year in organic products and want to use the organic label must be certified by a USDA 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 operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Resource Center web page. See more certification details in this guide under Section 3.1: Organic Certification Site Requirements.

Who does NOT need to be certified?

Producers and handling (processing) operations that sell less than $5,000 a year in organic agricultural products. Although exempt from certification, these producers and handlers must abide by the national standards for organic products and may label their products as organic. Handlers, including final retailers, that: do not process or repackage products; only handle products with less

than 70 percent organic ingredients; process or prepare, on the premises of the establishment, raw and ready-to-eat food labeled organic; choose to use the word organic only on the information panel; and handle products that are packaged or otherwise enclosed in a container prior to being received by the operation and remain in the same package. More information can be found at the National Organic Program USDA Agricultural Marketing Service website.

1.2 Organic Farm Plan

An organic farm plan is central to the certification process and is a good management tool, regardless. The farm plan describes production, handling, and record-keeping systems, and demonstrates to certifiers an understanding of organic practices for a specific crop. The process of developing the plan can be 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 farm plan is from the NOP web site:

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

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

It is important to note that the USDA National Organic Program requires that applicants for certification must keep accurate post-certification records for 5 years concerning the production, harvesting, and handling of agricultural products that are to be sold as organic. These records must document that the operation is in compliance with the regulations and verify the information provided to the certifying agent. Access to these records must be provided to authorized representatives of USDA, including the certifying agent.

2. SOIL HEALTH

Healthy soil is the basis of organic farming. Regular additions of organic matter in the form of cover crops, compost, or manure create a soil that is biologically active, with good structure and capacity to hold nutrients and water (any raw manure applications should occur at least 120 days before harvest). Decomposing plant materials will support a diverse pool of microbes, including those that break down organic matter into plant-available nutrients as well as others that compete with plant pathogens in the soil and on the root surface. The practice of crop rotation to promote a healthy soil should be initiated in the one or two years prior to planting establishment. 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, 3rd edition, by Fred Magdoff and Harold Van Es, 2009, available from www.sare.org/publications/soils.htm, SARE, Sustainable Agriculture Research and Education. For more information, refer to the Cornell Soil Health website, www.hort.cornell.edu/soilhealth.

3. SITE SELECTION

For organic strawberry production, the importance of proper site selection and preparation cannot be over-emphasized. Strawberries are usually grown for two to three years in organic production systems, bearing fruit in the second and third years. This approach maximizes yields while soil nitrogen content remains at acceptable levels. Consider that an ideal site should be close to your markets, be of sufficient acreage to allow for crop rotations, have available water of acceptable quality for irrigation and frost control, have well-drained soil, and good air drainage (slopes of 3-4% preferably facing north and away from prevailing winter winds). Sites should not have recently been cropped to plants susceptible to Verticillium wilt.

Conduct needed site improvements prior to planting. Once strawberries are planted it is very difficult to make major changes to improve soil and air drainage, or to modify soil tilth, pH, or nutrient status. Improving soil structure or eliminating soil compaction layers in an established planting rarely prove feasible given the few years the crop is in the ground.

Weather plays a critical role in site selection, as well. The macroclimate, mesoclimate and microclimate of a strawberry site play important roles in variety selection and potential profitability. Of particular importance are the potential for spring frosts, winter minimum temperatures, length of the growing season, and growing season heat accumulation. More detailed information on the site selection information presented here also can be found in Strawberry Production Guide for the Northeast, Midwest and Eastern Canada, NRAES-88.

A web-based, interactive site selection tool, the New York Vineyard Site Evaluation System, www.nyvineyardsite.org, uses specific climate information with a 3 kilometer resolution, based on 30 years of weather data, to determine the suitability of your site for different grape varieties. Although the tool was developed for vineyards, the map-based system integrates information on climate, topography, soils, and winter low temperatures much of which may be applicable to site selection for strawberry varieties across the state.

3.1 Organic Certification Site Requirements

The National Organic Program has requirements that affect site selection. Fields must not have been treated with prohibited products for three years prior to harvest of the certified organic crop. Mandated one-year crop rotation out of strawberries must be observed, though a 3-5 year rotation is typical. Adequate buffer zones must exist between certified organic and conventionally grown crops to prevent drift of prohibited materials onto certified organic crops. The buffer zones must be either a barrier (diversion ditch or dense hedgerow) or an area of sufficient size. The buffer zone 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. Check with your certifier for specific buffer requirements. Buffer zone sizes commonly range from 20 to 250 ft, depending on adjacent field practices. Buffers can include windbreaks and living barriers such as a dense hedgerow. A dense hedgerow less than 50 ft wide may offer better protection from contamination than a 50-ft-wide open buffer zone. The National Organic Farmers Association of New York (NOFA NY) standards prohibit a field's buffer zone to be planted to the same crop, with the exception of hay and pasture fields. Crops grown in the buffer zone may not be marketed as certified organic, or used for feed or bedding for certified organic livestock or dairy cattle.

3.2 Soil and Air Drainage and Soil Depth

Preparations for a strawberry planting should begin at least one year in advance. Selecting a site with good air and water drainage is essential for successful organic production. A nutritionally healthy planting in a well-drained soil with exposure to air movement is least susceptible to damage from pests and frosts.

Strawberries need good internal soil drainage to grow and do best on a well-drained sandy loam. Wet soils restrict root growth and respiration, resulting in weak growth and reduced yields. Coarse-textured soils have excellent soil drainage, but heavier soils, or soils with perched water tables often need drainage tiles to remove excess water and improve internal soil drainage. Drainage tile is best installed before planting. Local soil and water conservation districts and private tiling contractors can provide technical assistance in designing a drainage plan, but keep in mind that many base their designs on annual row crops. Perennial crops often require more intensive drainage than annual row crops. Planting on raised beds or on berms is useful to improve soil drainage in the rooting zone. Strawberries should not be grown on heavy clay soils. Because of the need for frequent light cultivation to manage weeds, stony and gravelly soils can also prove difficult.

Air drainage is an important consideration in choosing a strawberry field site. Cold air, like water, runs down hill, and collects in low areas or areas where trees or hedgerows obstruct airflow. These 'frost pockets' increase the risk of both mid-winter cold injury and spring frosts. Selecting a site with a gentle slope (3-4%) and good air drainage will reduce the risk of cold or frost injury. Good air drainage will also promote faster drying of foliage, flowers and fruit which will reduce the duration and frequency of disease infection periods. Good air drainage is essential to an organic disease management strategy.

Although strawberries can be grown on a wide variety of soils, shallow soils have less water holding capacity and will limit root development, resulting in smaller plants with smaller crops. Rooting depth of 12 inches or more is considered important for adequate plant growth and cropping levels. Digging test soil pits can help you evaluate potential rooting depth and drainage issues and evaluate what measures to take to address soil management issues before planting.

3.3 Soil Testing

Knowing all you can about the soil of a potential strawberry site will allow for better management decisions prior to planting. Soil testing is recommended to provide information on pH, availability of major and minor nutrients, organic matter and cation

exchange capacity. A pH of 6.0 to 6.5 is suggested for most strawberry varieties. See Table 6.1 for soil and tissue testing laboratories and refer to section 6, Nutrient Management, for more information.

A nematode analysis performed on representative soil samples is a wise step in the year or two prior to planting since it will allow time for using a cover crop to reduce plant parasitic nematode populations, see section 4, Cover Crops, for more information. Samples may be submitted for nematode testing to the Plant Disease Diagnostic Clinic, College of Agriculture and Life Sciences, Ithaca, NY. For more information and fee schedules visit their website at www.plantclinic.cornell.edu. The best time for collecting samples for nematode testing is during summer, when soils are moist, not dry. A minimum of 6 soil subsamples, approx. 1″ diameter and 4″ deep should be collected randomly from an area approx. ½ acre in size. Gently mix samples together, transfer about 1 pint of mixed soil to a plastic bag, and ship as soon as possible to the diagnostic lab. Refrigerate sample if it cannot be shipped immediately.

3.4 Previous Cropping History

Another factor to consider when selecting a site is previous cropping history. The Verticillium wilt fungus may persist many years in soil and is devastating to strawberries under conditions favorable for disease development. If possible, avoid sites where potatoes, tomatoes, eggplants, or brambles have recently been grown and, to a lesser extent, squash, cucumber, pepper, or melons. These crops serve as hosts to Verticillium wilt. Many weeds are also hosts of the Verticillium fungus, particularly nightshade, groundcherry, redroot pigweed, lambsquarters, and horsenettle. Weeds should be strictly controlled in current and future planting sites to keep Verticillium inoculum low. Rotating to non-susceptible grasses and cereals (5-8 year rotation) will reduce the amount of Verticillium inoculum in infested soil, but seldom eliminates it. Brassica crop rotations (mustards, broccoli, Brussels sprouts) are recommended where Verticillium wilt is present or has been observed in the past. Brassicas should be grown for a 2-yr period and crop residues incorporated into the soil. Practice long rotations out of strawberry and plant resistant varieties, including Earliglow, Guardian, Allstar, Tribute, and Tristar where Verticillium wilt is a problem.

3.5 Irrigation Water Source

Another important criterion to consider when selecting a strawberry site is irrigation water quantity and quality. The irrigation water source should provide sufficient volume of water to irrigate as needed during the growing season. The irrigation system should be in place prior to planting to insure availability of water to the new transplants and to provide frost protection on cold nights during bloom. Trickle irrigation uses water more efficiently than overhead irrigation, but overhead irrigation can be used for frost protection. With trickle systems, row covers are required for frost protection in the absence of overhead irrigation. Summer-fruiting strawberries, grown in a matted row system, typically require 1 to 2 inches of rainfall per week, or 25 to 30 inches per season. The critical periods when strawberries require sufficient water to optimize growth and yield are during the fruiting period and after renovation. Be sure to have a water test done on irrigation water sources prior to site selection to determine its physical, chemical, and biological constituents. Irrigation water pH should be 7.0 or below, and should also have a low salt content (<2.0 ds/m; preferably <1.0 ds/m;) as strawberries are a salt-sensitive fruit crop. Always check with your certifier on the products used for lowering irrigation water pH. Water contaminated with sewage or manure should not be used to irrigate strawberries. Use only potable water to irrigate strawberries during bloom and harvest. For more information on irrigation see: Strawberry Production Guide, NRAES-88.

4. COVER CROPS

Cover crops are grown for their valuable effect on soil properties, such as organic matter, and, in strawberries, on their preplant ability to eliminate or suppress weeds, provide nutrients to the plants, and reduce nematode populations. They can also improve water infiltration into the soil, maintain populations of beneficial fungi, and may help control insects and diseases. To be effective, cover crops should be treated as any other valuable crop on the farm, with their cultural requirements carefully considered and met, including nutrient requirements; susceptibility, tolerance, or antagonism to root pathogens and other pests; life cycle; and mowing/incorporation methods. See Table 4.1 for more information on specific cover crops.

4.1 Goals and Timing for Cover Crops

Cover crops play an important role in a strawberry planting, especially during the years prior to planting through improvement of soil organic matter, breaking up of compaction layers, erosion control, and suppression or elimination of weeds. Goals should be established for choosing a cover crop; for example, the crop can add nitrogen, smother weeds, or reduce nematode populations. The cover crop might best achieve some of these goals if it is in place for an entire growing season and incorporated into the soil prior to plant establishment.

Table 4.1. Cover Crops for Strawberries: Cultural Requirements and Crop Benefits					
Species	**Planting Dates**	**Life Cycle**	**Soil Type Preference**	**Seeding (Lb/A)**	**Comments**
Alfalfa [1]	early April-late May	Perennial	Well-drained, high pH (6.0-7.0)	14	+May be difficult to incorporate if allowed to overwinter +Inoculate seed with nitrogen-fixing bacteria, if seeded in a field for the first time
Brassicas e.g. mustards, rapeseed	April OR late Aug.-early Sept.	Annual / biennial	Loam to clay	5-12	+Good dual purpose cover & forage +Establishes quickly in cool weather +Mow or incorporate before seed formation +Biofumigant properties
Buckwheat	Late spring-early summer	Summer annual	Most	35-134	+Rapid grower (warm season) +Good catch or smother crop +Good short-term soil improver for poor soils +Mow or incorporate before seed formation +Will winter kill
Cereal Rye	August-early October	Winter annual	Sandy to clay loams	60-200	+Most cold-tolerant cover crop +Excellent allelopathic weed control +Good catch crop, rapid germination & growth +Mow or incorporate before seed formation +Temporary nitrogen (N) tie-up when turned under
Fescues fine (red, hard) tall	April-May OR late Aug.-Sept.	Long-lived perennial	Most	70-100	+Very good low-maintenance permanent cover, especially in infertile, acid, droughty &/or shady sites +Can be incorporated preplant +Tall fescue has high vigor, requires more frequent mowing, and has moderately high water use +Fine fescues have low vigor, require less frequent mowing, and have moderate water use
Marigold	Late May-June	Annual	Most	5-10	+Will winter kill +Biofumigant properties
Oats	Mid-April OR late Aug.-mid Sept.	Summer annual	Silt & clay loams	60-100	+Incorporate in late June when planted in the spring +Rapid growth +Ideal quick cover crop +When planted in late summer, will winter kill
Ryegrass	August-early Sept.	Winter annual OR short-lived perennial	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	NI	50-90	+Tremendous biomass producers in hot weather +Good catch or smother crop +Biofumigant properties
Sweet Clover [1]	early April-mid May OR early August	Annual / biennial	Most	12-20	+Good dual purpose cover & forage +Does not need added nitrogen +May need to be mowed prior to incorporating +Mow or incorporate before seed formation
Vetch [1]	August	Annual / biennial	Most	30-40	+Does not need added nitrogen +Mow or incorporate before seed formation
Wheat	Early-mid Sept.	Winter annual	Most	80-100	+Mow or incorporate before seed formation

Adapted from M. Sarrantonio. 1994. Northeast Cover Crop Handbook; the Mid-Atlantic Berry Guide for Commercial Growers. 2008. Penn State Univ; the Pest Management Guidelines for Berry Crops. 2009. Cornell Univ.; and M. Pritts and D. Handley, eds. 1998. Strawberry Production Guide, NRAES-88.

[1] Legumes may benefit from inoculation of seed with nitrogen-fixing bacteria when planted in a field for the first time. Check with your certifier for allowable sources of inoculum.

Cover crops planted in late summer will suppress annual weed growth, improve soil texture, provide organic matter, and may increase soil nitrogen. The cover crop can be incorporated in late fall or in early spring before planting. Certain cover crops (marigold, sudangrass) will either suppress or resist nematode populations. In addition to producing large amounts of biomass that out-compete other plant species, some cover crops (annual rye, ryegrass) can inhibit weed growth through allelopathy, the chemical inhibition of one plant species by another. Rye provides allelopathic suppression of weeds when used as a cover crop, and when crop residues are retained as mulch. Rye residues retained on the soil surface release chemicals that inhibit germination and seedling growth of many grass and broadleaf weed species. Retention of residue on the soil surface can be accomplished by mowing before seed head formation.

See Cornell's online decision tool to match goals, season, and cover crop. Although written for vegetable growers it has comprehensive information on various cover crops. Another resource for determining the best cover crop for your situation is the *Northeast Cover Crop Handbook*, by Marianne Sarrantonio.

Allowing cover crop residue to remain on the soil surface might make it easier to fit into a crop rotation and will help to conserve soil water. Keep in mind that 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 decomposition and nitrogen release from the crop residue. Cover crops such as grasses with low nitrogen content should be plowed under in the fall to allow time for decomposition prior to planting strawberries. Legumes which contain more nitrogen and decompose more quickly can be plowed under within a month of planting.

4.2 Legumes

Legumes are looked to as a potential nitrogen source. Legumes may benefit from inoculation of seed with nitrogen-fixing bacteria when planted in a field for the first time. Check with your certifier for allowable sources of inoculum. Legumes such as red clover and hairy vetch will often benefit from having a nurse crop planted simultaneously, usually a small cereal grain such as wheat or rye. These nurse crops establish faster than legumes and provide soil stability and reduce weed pressure during establishment, and provide support for the newly growing legumes before winter. To receive the full nitrogen benefit from planting legumes, they need to be incorporated into the soil just as they start to bloom, which is usually in late spring. (Source: Bjorkman, T. *Cover Crops for Vegetable Growers*.)

5. VARIETY SELECTION

Key considerations in variety selection include the market destination and whether June-bearing or dayneutrals will be grown. Consider whether the strawberries will be shipped and, if so, choose varieties with good shelf life and shipping quality. Flavor varies considerably between varieties, too, and may be inversely related to shipping quality. Flavor may fluctuate depending on soil type, plant nutrition, and irrigation. Determine whether flavor or shipping quality are most important to your market and choose varieties accordingly. More information about strawberry varieties is available online, in the Strawberry Production Guide for the Northeast, Midwest, and Eastern Canada, NRAES-88 (available for purchase from: www.nraes.org/), and in nursery catalogs.

In organic strawberry production, the variety's relative resistance or susceptibility to diseases is vital because of the limited number of organic fungicides that are available for disease management. June-bearing varieties considered to have the best potential for organic production in New York State include:

Earliglow (early season)
Itasca (early/midseason)
Mesabi (midseason)
Scott (midseason)
Allstar (mid/late season)

Varieties vary widely in their susceptibility to fungal diseases and some may be less susceptible to insects. If susceptible varieties are planted, the importance of site, sanitation and cultural practices will increase in accordance to the variety's susceptibility. Table 5.1 lists the relative disease susceptibility of many of the strawberry varieties grown in the Northeast. This is not an inclusive list and does not represent all varieties that are, or have been, grown organically in New York State. Varieties for which disease resistance ratings were not available at the time this guide was written include Bounty, Darselect, Evangeline, Evita, Covernor Simcoe, Micmac, Seascape, Veestar, and Vesper.

Table 5.1. Relative disease susceptibility among strawberry varieties[1]

	Disease susceptibility [a]						
Variety	**LSc**	**LSp**	**LB**	**RS**[b]	**PM**	**VW**	**AT**
Albion	U	I	U	R	I	R	I
Allstar	T-R	S-T-R	S	R-VR	T-R	I-T-R	VS
Annapolis	S	S	U	T-R	S	S	U
Blomidon	U	U	U	S	U	U	U
Cavendish	R	R	U	R	U	T-R	U
Canoga	R	R	U	I	U	I	U
Chandler	U	S	S	S	R	U	VS
Clancy	T	T	T	R	R	R	R
Earliglow	R	S-I-R	S	I-R	S-I-R	I-T-R	S
Evie II	U	U	U	T	T	T	U
Guardian	R	S-I-R	U	R	S-R	S-T-R-VR	U
Glooscap	R	R	U	S	U	I	U
Honeoye	T-R	S-T-R	U	S	S-I	S	U
Idea	U	U	U	R	U	U	U
Jewel	R	R	U	S	T	S	U
Kent	I-R	S-R	U	S	S	S	U
L'Amour	T	T	T	T	R	R	R
Lateglow	T-R	T_R	S	R	S	R-VR	U
Latestar	U	U	S	R	U	U	U
Lester	R	R	U	R	R	S-R	U
Mesabi	T	T	U	R	U	R	U
Mira	U	U	U	R	U	U	U
Northeaster	T	T	U	R	U	R	U
Ozark Beauty	U	R	U	S	U	S	U
Raritan	S	S	U	S	S	S-I	U
Redchief	R	S-R	VS	R	S-R	I-R	VS
Scott	S-I-R	S-T	VS	S-R	R	S-I-R	VS
Sparkle	S-I	S-R	U	S-R	R	I-S	U
Tribute	T	T	U	R-VR	R	T-R	U
Tristar	T	T	U	R	R	R	U
Wendy	T	S	U	I	T	S	U
Winona	R	R	U	R	U	T	U

Key: VS = very susceptible, S = susceptible, I = intermediate, T = tolerant, R = resistant, VR = very resistant, U =unknown. Where multiple letter designations are given, ratings varied at different research sites.

[1]The relative ratings in this chart apply to an average growing season. Under conditions favorable for disease development, any given variety may be more severely affected.

a. LSc=Leaf Scorch, LSp=Leaf Spot, LB=Leaf Blight, RS=Red Stele, BRR=Black Root Rot, PM=Powdery Mildew, VW=Verticillium Wilt, AT=Anthracnose.

b. Varieties are not resistant to all races of the red stele pathogen.

Growers must also consider where they obtain their planting stock. According to language in the USDA-NOP regulation §205.202, "the producer must use organically grown seeds, annual seedlings, and planting stock. The producer may use untreated nonorganic seeds and planting stock when equivalent organic varieties are not commercially available. Seed and planting stock treated with substances that appear on the National List may be used when an organically produced or untreated variety is not commercially available. Planting stock used to produce a perennial crop may be sold as organically produced planting stock after it has been

maintained under a system of organic management for at least 1 year. Seeds, annual seedlings, and planting stock treated with prohibited substances may be used to produce an organic crop when the application of the substance is a requirement of Federal or State phytosanitary regulations." With the limited availability of organically certified strawberry stock, growers will likely be able to justify the use of non-organic stock to their certifying agency.

6. NUTRIENT MANAGEMENT

To produce a healthy crop, soluble nutrients must be available from the soil in amounts that meet the minimum requirements for the whole plant. The challenge in organic systems is balancing soil fertility to supply required plant nutrients at a time and at sufficient levels to support healthy plant growth. Restrictions in any one of the needed nutrients will slow growth and can reduce crop quality and yields. In strawberry plantings, the key considerations when managing nutrition organically include preplant soil pH and nutrient adjustments; nutrition in established plantings; and understanding carbon to nitrogen ratios to deliver appropriate amounts of nitrogen to the crop.

Organic growers often speak of feeding the soil rather than feeding the plant. A more accurate statement is that organic growers focus their fertility program on feeding soil microorganisms rather than the plant. Soil microbes decompose organic matter to release nutrients and convert organic matter to more stable forms such as humus. This breakdown of soil organic matter occurs throughout the growing season, depending on soil temperatures, water availability and soil quality. The released nutrients are then held on soil particles or humus 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.

One goal of the grower is to optimize resource use efficiency (land, water, nutrients) to optimize plant growth and fruit yield. Plant size and yield can be influenced by water and nutrient supply (i.e. adequate water is needed for adequate nutrient uptake). Weak plants with few, small leaves will intercept insufficient sunlight to produce adequate yields in the current season or to develop flower buds for the next season. Conversely, over-stimulated plants with abundant large, dark green leaves have low water use efficiency, are more prone to winter injury, diseases and insect feeding, and produce fewer fruit. Organic strawberry plantings should strive to balance soil nutrient availability—via irrigation, organic matter content, soil pH, and microbial activity—with plant growth and production goals.

Nutrient demand is greatest during leaf and fruit development in spring when reserve nutrients carried over from the previous year have been used up and the plant is actively growing. Plant age, vegetative growth, and fruit yield are the deciding factors in determining the need for nutrients during the growing season.

6.1 Soil and Leaf Analysis

Regular soil and leaf analysis helps monitor nutrient levels. Choose a reputable nutrient testing lab (see Table 6.1) and use it consistently to avoid discrepancies caused by different extraction methods. It is recommended that leaf testing be incorporated into a fertility management program with soil testing to assist in determining the plants' nutrient status and to make sure that what is in the soil is making it into the plants in the proper amounts. It is recommended that soil and leaf tests be completed in each block. Leaf testing is especially crucial in getting the information needed to make management decisions in problem areas of the planting and should be used on a more frequent basis, if needed.

Table 6.1. Nutrient Testing Laboratories

Testing Laboratory	Web URL	Soil	Leaf	Compost/ Manure	Forage
Agro-One (Cornell Recommendations)	www.dairyone.com/AgroOne/	x	x	x	x
Agri Analysis, Inc.	www.agrianalysis.com/		x	x	
A&L Eastern Agricultural Laboratories, Inc.	www.al-labs-eastern.com/	x	x	x	
Penn State Agricultural Analytical Services Lab.	www.aasl.psu.edu/	x	x	x	
University of Massachusetts	www.umass.edu/plsoils/soiltest/	x	x	x	
University of Maine	anlab.umesci.maine.edu/	x	x	x	x

Table 6.2 gives the target values for strawberry leaf nutrients sampled in late July or early August in the Northeast. Regular soil testing helps monitor nutrient levels, in particular phosphorus (P) and potassium (K). The source of these nutrients depends on soil type and historic soil management. Some soils are naturally high in P and K, or have a history of manure applications that have resulted in elevated levels. Additional plant available nutrients are supplied by decomposed soil organic matter or through specific soluble nutrient amendments applied during the growing season in organically managed systems. Many types of organic fertilizers are available to supplement the nutrients supplied by the soil. ALWAYS check with your certifier before using any product to be sure it is approved.

Table 6.2. Deficient, sufficient, and excessive nutrient concentrations in strawberry leaves.

		Target values (ppm, unless otherwise noted)		
Nutrient	**Symbol**	**Deficient Below**	**Sufficient**	**Excess Above**
Nitrogen	N	1.90%	2.00-2.80%	4.00%
Phosphorus	P	0.20%	0.25-0.40%	0.50%
Potassium	K	1.30%	1.50-2.50%	3.50%
Calcium	Ca	0.50%	0.70-1.70%	2.00%
Magnesium	Mg	0.25%	0.30-0.50%	0.80%
Sulfur	S	0.35%	0.40-0.60%	0.80%
Boron	B	23	30-70	90
Iron	Fe	40	60-250	350
Manganese	Mn	35	50-200	350
Copper	Cu	3	6-20	30
Zinc	Zn	10	20-50	80

Adapted from: Pritts (1998) Soil and Nutrient Management. Chpt 7 In: Strawberry Production Guide. M. Pritts and D. Handley (eds.). NRAES-88. Ithaca, NY.
Note: ppm is parts per million.
% by dry weight of strawberry leaf

6.2 Soil pH

Maintaining a soil pH range of 6.0 to 6.5 is recommended for strawberries. Use the soil test results to determine the appropriate amount of lime (raise pH) or sulfur (lower pH) to apply. The lime or sulfur requirement will depend on soil texture, current pH, and organic matter content. Follow the recommendations of the soil test and apply and incorporate sufficient lime or sulfur prior to planting. It typically takes one year for the applied lime or sulfur to raise or lower the soil pH, respectively. The slightly acid soil pH of 6.0-6.5 is required to help avoid micronutrient deficiencies.

Prilled sulfur formulations are preferred for soil application because they are easier to work with, provide better coverage, and are cheaper than powdered sulfur. Prilled sulfur takes about one year or more to oxidize and reduce soil pH. Likewise, finely ground lime is more difficult to work with, but it will raise the soil pH faster than coarse particles.

6.3 Managing Nutrients

Follow the recommendations of the soil test when adding nutrients to prepare a site for planting. Pay particular attention to the soil test results for potassium, phosphorus, magnesium, calcium, and boron. If interpreting your own soil tests, it is important to know the phosphorus extraction method used by your analytical lab in order to get a proper recommendation. When preplant recommendations are followed, additional potassium and phosphorus likely will not be required unless the soil is very sandy. However, potassium (K) demand by strawberry plants is relatively high, so make certain there is sufficient available potassium in the soil preplant. Boron is frequently low in fruit plantings throughout the Northeast. If boron is required, then apply no more than 2 lb/acre actual boron in any one year. Refer to CALCULATING THE AMOUNT OF PESTICIDE TO USE and Tables 8.1, 8.2, and 8.3 in Section 8.1 for converting amounts per acre to amounts needed for smaller areas and for measuring and mixing small amounts.

Table 6.3. Available Potassium in Organic Fertilizers

Sources	Pounds of Fertilizer/Acre to Provide given Pounds of K_2O per acre: 20	40	60	80	100
Sul-Po-Mag 22% K_2O also contains 11% Mg	90	180	270	360	450
Wood ash (dry, fine, grey) 5% K_2O, also raises pH	400	800	1200	1600	2000
Alfalfa meal* 2% K_2O, also contains 2.5% N and 2% P	1000	2000	3000	4000	5000
Greensand or Granite dust 1% K_2O (x 4)**	8000	16000	24000	32000	40000
Potassium sulfate 50% K_2O	40	80	120	160	200

*Only non-GMO sources of alfalfa may be used. Check with your certifier.

**Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Should be broadcast and incorporated prior to planting.

Table 6.4. Available Phosphorous in Organic Fertilizers

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

* Application rates for some materials are multiplied to adjust for their slow to very slow release rates. Should be broadcast and incorporated prior to planting.

In established plantings, base fertilizer amounts on leaf analysis. In the event that potassium is required, a reasonable amount of potassium to apply, preferably in the fall, is up to 100 lb/acre. See table 6.3 for organic sources of potassium. Pay attention to the K/Mg ratio and if it is above 4, then additional magnesium should be applied with the potassium fertilizer to prevent inducing a magnesium deficiency: the K/Mg ratio should be less than 5.

Magnesium (Mg) deficiency in strawberry is quite common. Factors that influence magnesium availability include soil pH and excess potassium. In established plantings that are low to deficient in magnesium, typical recommendations would be for 10-40 lb/acre actual magnesium, but follow recommendations of the leaf analysis.

Boron is frequently low in fruit plantings throughout the Northeast. If boron is required, then apply no more than 2 lb/acre actual boron in any one year. The best time to apply boron is after leaves are mowed at renovation. Check with your certifier for information on allowable sources of magnesium and boron.

Phosphorus demand by strawberry is relatively low, and phosphorus is usually not required in established plantings. Table 6.4 lists some organic fertilizer sources of phosphorus.

6.4 Preparing a Nitrogen Budget

The carbon to nitrogen (C/N) ratio in compost can provide a guide for nitrogen release into the soil solution. When a decomposing material has a low C/N ratio (a lot of nitrogen) microbes release the excess nitrogen into the soil solution. When a material undergoing decomposition has an initially high C/N ratio (very little nitrogen), microbes will use whatever nitrogen is available for their own growth, leaving little for plants. This can result in temporary nitrogen deficiency. Once the decomposition process begins to slow and those microbes die off, they will release their nitrogen back into the soil where it will become available to plants. The rule of thumb is that if the C/N ratio is less than 20 or the material's nitrogen content is greater than 2.5%, then there will be enough nitrogen available for both decomposer microbes and plants. If the C/N ratio is above 20, then nitrogen will likely be immobilized until sufficient decomposition has taken place. One reason for applying nitrogen fertilizer at renovation is to help overcome the temporary nitrogen deficiency that will occur when the straw (with a high C/N ratio) is worked into the soil.

Develop a plan for estimating the amount of nutrients that will be released from soil organic matter, cover crops, compost, and manure. Submit soil samples for a Cornell Soil Health Test. This test includes an estimate of nitrogen mineralization rate, which indicates the potential release of N from soil organic matter. Test results will provide feedback on how the soil sample compares to other New York soils. The results can also be useful for monitoring changes in the nitrogen mineralization rate over time and during the transition to organic production.

Management of N, and insuring adequate supply at the times of crop need, requires some planning. Prepare a nitrogen budget for organic production to estimate the amount of N released by various organic amendments as well as native soil organic matter. Examples of manures and their nutrient content are shown in Table 6.5. Compost and manure should be tested for nutrient content

at an analytical lab, and cover crops can be tested at a forage testing lab (Table 6.1). Knowing these values will help evaluate if the budget plan is providing appropriate amounts of N during the season by comparing them to the nitrogen guidelines for strawberries (Table 6.6)

Table 6.5. Estimated Nutrient Content of Common Animal Manures

	N	P_2O_5	K_2O	N1[1]	N2[2]	P_2O_5	K_2O
	NUTRIENT CONTENT LB/TON			*AVAILABLE NUTRIENTS LB/TON IN FIRST SEASON*			
Dairy (with bedding)	9	4	10	6	2	3	9
Horse (with bedding)	14	4	14	6	3	3	13
Poultry (with litter)	56	45	34	45	16	36	31
Compost (from 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*	20+	44	23
Dairy (liquid)	28	13	25	14*	11+	10	23

1-N1 is the total N available for plant uptake when manure is incorporated within 12 hours of application.
2-N2 is 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.
* injected, + incorporated.
Adapted from *"Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops"* by Carl Rosen and Peter Bierman and Penn State Agronomy Guide 2007-8.

Using the values from your soil test, estimate that 20 lbs. of nitrogen will be released from each percent organic matter in the soil. From the test of total N in any manure applied, estimate that 50% is available in the first year, and then 50% of the remaining is released in each of the next two years. So, for an application rate of 100 lbs. of N as manure, 50 lbs. would be available the first year, 25 lbs. the second, and 12.5 lbs. the third. Remember to check with your certifier on the days-to-harvest interval when using raw manure and allow a minimum of 120 days between application and harvesting. To prevent run-off, do not apply raw manure to bare ground in established strawberry plantings.

Estimate that between 10% and 25% of the N contained in compost will be available the first year. It is important to test each new mix of compost for actual amounts of the different nutrients available. Compost maturity will influence how much N is available. If the material is immature, more of the N may be available to the crop in the first year. A word of caution: Using compost to provide for a crop's nutrient needs is not generally a financially viable strategy. The total volume, trucking, and application can be very expensive for the units of N available to the crop. Most stable composts should be considered as soil conditioners, improving soil health, microbial diversity, tilth, and nutrient retaining capacity.

Add together the various N values from these different organic sources to estimate the N supplying potential of the soil. 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 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. 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 helping build this type of diverse biological community and ensuring long-term organic soil and crop productivity.

The annual nitrogen guidelines for strawberries are outlined in Table 6.6. Use leaf analysis for determination of nutrient status in established plantings, and adjust nitrogen fertilization accordingly (see section 6.1). The primary challenge in organic systems is synchronizing nutrient release from organic sources, particularly nitrogen, with crop requirements. In cool soils, microorganisms are less active, and nutrient release may be too slow to meet the crop needs. Once the soil warms, nutrient release may exceed crop needs. In a long-term organic nutrient management approach, most of the required crop nutrients would be in place as organic matter before the growing season starts. Nutrients needed 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 6.5 and 6.7). These products can be expensive,

so are most efficiently used if applied in a 1 foot band over the plant row, splitting applications between May and early June. Be aware that spring applications of nitrogen can greatly increase the risk of gray mold fruit rot infections.

Table 6.7 lists some commonly available fertilizers, their nutrient content, and the amount needed to provide different amounts of available nitrogen, Adapted by Vern Grubinger from the University of Maine soil testing lab.

Table 6.6. Annual Nitrogen Guidelines for Strawberries.

Planting Age (years)	Amount Actual N (lbs/Acre)	Time of Year to Apply
0	30	early June[a]
	30	early Sept[a]
1+	70	at renovation
	30	early Sept[b]

[a] Be sure plants are growing well prior to application.
[b] Adjust amount based on leaf analysis.

Table 6.7. Available Nitrogen in Organic Fertilizers

	Pounds of Fertilizer/Acre to Provide given Pounds of N per Acre				
Sources	**20**	**40**	**60**	**80**	**100**
Blood meal 13% N	150	310	460	620	770
Soy meal 6% N (x 1.5)*, also contains 2% P and 3% K_2O	500	1000	1500	2000	2500
Fish meal 9% N, also contains 6% P_2O_5	220	440	670	890	1100
Alfalfa meal 2.5% N also contains 2% P and 2% K_2O	800	1600	2400	3200	4000
Feather meal 15% N (x 1.5)*	200	400	600	800	1000

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

7. ORGANIC STRAWBERRY IPM

Organic production of strawberries is challenging in New York State given the abundant rainfall during the growing season leading to increased pressure from diseases, insects and weeds. However, growers in New York and the eastern United States, through proper variety and site selection, strict attention to cultural practices and sanitation, and increased attention paid to scouting plantings on a weekly basis to catch pest outbreaks early, have succeeded in producing quality organic strawberries. In contrast, a failure to appreciate the risk of disease, insect and weed development, and failure to devise and implement a season-long (and multiyear) management strategy, can lead to serious crop and even plant losses in particular years. Successful IPM is essential to the sustainable production of organic strawberries.

7.1 Developing a Strawberry IPM Strategy

1. Examine your strawberry operation closely. Break it down into specific plantings, or "strawberry blocks."
2. Produce a map of each planting (or block) to record weeds, pest outbreaks, nutrient deficiencies, drainage problems, missing plants, and any other abnormalities you find.
3. Develop a record-keeping system for each planting or block.
4. Develop a scouting plan for each block and record results.
5. Monitor and record weather factors and understand basic weather patterns of the area.
6. Keep accurate records of spray applications, tools, or tactics used to manage pests.
7. Properly maintain your spray equipment, calibrate the sprayer, select appropriate nozzles, and reduce spray drift. Consult the Pesticide Application Technology website at Cornell University: www.nysaes.cornell.edu/ent/faculty/landers/pestapp/ or the Strawberry Production Guide for the Northeast, Midwest, and Eastern Canada, NRAES-88 available for purchase from: www.nraes.org/.
8. Develop a thorough knowledge of the strawberry pests you are likely to encounter during the year. This includes basic pest biology, symptoms or damage, whether they are a primary or secondary pest, scouting thresholds, and the best time to apply management practices.
9. Choose a pest management strategy for the planting (or block) that is based on all of the information you've gathered. Use the options that make the most sense for your operation.
10. Continue your pest management education.

Other resources available online, include:
New York State IPM website: nysipm.cornell.edu/fruits/
Cornell Fruit Resources: www.fruit.cornell.edu
New York State berry IPM insect and disease fact sheet index: nysipm.cornell.edu/factsheets/berries/
Cornell University Pesticide Management Education Program: pmep.cce.cornell.edu/
Pesticide Application Technology at Cornell University: www.nysaes.cornell.edu/ent/faculty/landers/pestapp/
Elements of IPM for Strawberries in New York State www.nysipm.cornell.edu/elements/strawb.asp
Network for Environment and Weather Applications (NEWA) newa.cornell.edu
Berry Diagnostic Tool www.hort.cornell.edu/diagnostic

7.2 Weed Management

Weed management is a major challenge for strawberry growers. Weeds are part of the strawberry planting ecosystem and can compete for water and nutrients; provide alternate hosts for pests; and interfere with planting operations. Weed growth can also alter the microclimate around plants, leading to higher disease pressure. In organic production, site preparation prior to planting spanning 2- to 3-years to eliminate weeds through cover cropping and cultivation will provide lasting benefits in weed control for the short-term perennial production cycle of strawberries. Table 7.1 outlines weed management practices in strawberry plantings.

Table 7.1. Weed management without herbicides in a strawberry planting.

Year	Month	Non-herbicidal options
Planting year*	**April - May**	Till to prepare for planting.
	May	Cultivate
***CRITICAL TIME FOR REDUCING WEEDS.**	**Mid-June after planting**	Cultivate.
	Mid-July	Cultivate.
	Mid-August	Cultivate.
	October	Cultivate.
	Late November	Mulch for winter protection.
Fruiting years	**March - April**	Remove mulch.
	Early May	Hand weed only.
	Late July after harvest	Mow leaves, narrow rows with a tiller.
	September	Cultivate.
	November	Mulch for winter protection.

Excellent preplant preparation with the goal of eliminating perennial weeds from the site before planting is essential. Good preplant preparation, use of cover crops, and crop rotation help reduce weed pressure considerably. Eliminating perennial weeds can be achieved with repeated cultivation and using "green manure" cover crops that are plowed under prior to planting. For more information on cover crops see section 4. Keep in mind that excessive cultivation can lead to undesirable consequences such as soil erosion, reduced soil organic matter, and breakdown in soil structure resulting in compaction and reduced permeability.

Minimizing weed competition during plant establishment is critical to achieve optimal plant growth and yields. Once plants are set, regular hand weeding, hoeing, and cultivation are required throughout the first year. Do not let weeds go to seed, and keep the surrounding area mowed to prevent weed seeds from migrating into the planting site. If a first year planting is healthy, dense, and weed free prior to winter, then weed problems will be much less in subsequent years. Some growers are planting in late May or early June at a higher density to reduce weed pressure.

Managing weeds within the row may be one of the most difficult tasks in the production of organic strawberries. Inorganic mulches like plastic can only be used in organic production if they are removed from the soil annually. There has been some recent research in Italy with the use of biodegradable mulch films (starch-based) that do not need to be removed from the soil. These materials have shown promise in New York strawberry plantings.

Organic mulches can also be used as tools for weed management. They are most effective where soil moisture and fertility are low and where low plant size restricts crop productivity. To provide adequate weed control, organic mulches must be at least 4 inches thick. Potential organic mulches include straw, hay, sawdust, and wood chips. Mulch matted row plantings with straw (wheat or rye works best) for winter protection, then rake the straw into the alleyways for additional weed suppression. Straw mulch may serve as a major source of weed seed; be sure to inspect straw before purchase. Use of straw or hay mulch between the rows for suppression of weed growth is also an excellent method of water conservation and increasing the soil organic matter. Financial assistance to help pay for mulch may be available from your county's Soil and Water Conservation District office.

There are a number of mechanical, thermal and animal measures that can be used to limit the effects of weeds in a strawberry planting. Mechanical and thermal options include fixed hoes, rotary cultivators, flamers, steamers, and hot water applicators. Animal weeders have also been used with some success in organic plantings across the United States. The use of weeder geese, guinea fowl, and sheep have some effectiveness, but due to food safety concerns regarding microbial contamination of food crops from manure they must be removed from the planting 90 days prior to harvest.

The mechanical brush hoe, in particular, showed promise for use in matted row strawberry production. Just two well-timed passes provided excellent seasonal weed control. The brushes moved runners back into the row, allowing cultivation to occur later in the season compared with other implements. The resulting layer of dust created by the implement "mulched" the field and suppressed weed seed germination.

Note: An organic herbicide strategy alone cannot provide satisfactory weed control for organic strawberry growers.

Organic Herbicides Labeled for Management of Weeds in Strawberry

Trade Name[1] (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[2]	Comments
GreenMatch *(citrus extract (d-limonene))*	14% solution	7	4	4	There are reports of some efficacy on some broadleaves such as *Brassica* species. Use a minimum of 60 gallons per acre sprayed. Do not exceed 8-1/2 gallons per acre per application.
Matran EC *(clove oil)*	5 – 8% solution	None listed	0	3	25(b) active ingredient. Trials on Long Island indicate very little efficacy, even when organic surfactants were used.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.3 Principles of Insect and Disease Management

While strawberry production may be severely limited by insect pests and plant diseases, an understanding of the factors involved in their development can ensure effective management. The development of disease and insect damage is highly dependent on characteristics and conditions of the crop (host), the pathogen/pest population, and the environment. These factors all must be conducive before disease development and/or considerable insect damage will occur.

Characteristics of the host that influence disease and pest susceptibility include the host's vigor, physiology, and variety (genetics). Aggressiveness or virulence, abundance, and physiology are characteristics of the pest or pathogen populations that influence their ability to cause disease or damage. At the same time, abiotic environmental conditions such as temperature, moisture, light, and soil chemistry can affect both the host and pest and may promote or prevent disease. Moreover, the presence, abundance and activity of natural enemies can play an important role in determining pest status. The most successful disease pathogens and insect pests have coevolved with their hosts over many years to incite disease and damage at the most opportune times. To successfully minimize disease and pest damage, the relevant aspects of the host, pathogen/pest, and environment must all be managed within specific timeframes.

Although insect pests and plant disease pathogens are vastly different in their biology, they often have enough similarity in life history strategies to allow successful management under a single set of underlying principles. These principles include avoidance/exclusion, eradication, and protection. They are defined below.

Avoidance/exclusion: This principle focuses on preventing pathogen introduction and minimizing factors that favor the establishment of pests and pathogens. Several practices that exclude or limit pathogen and pest presence include the following:

- Select sites with good soil drainage. Install tile in plantings with less than optimal drainage and/or incorporate raised beds or berms to further promote soil drainage.
- Choose sites with good air drainage. Promote air circulation by selecting an open site, removing dead or senescent plant material and reducing weeds; these practices allow fruit and leaves in berry plantings to dry more quickly.
- Plant only disease free and insect free planting stock.
- Prevent rain-splash dispersal of soil particles by applying a thick layer of mulch under and around plants.
- Practice weed management as weeds can be hosts for strawberry pathogens and arthropod (insect and mite) pests.
- Avoid planting strawberries in proximity to other crops or habitats that harbor large pathogen and/or pest populations.

Eradication: This principle is concerned with the destruction of pathogen/pest populations. These practices include:

- Sanitation of plantings by removal of infected/infested plant material including overripe fruit, leaf litter, and plants to eradicate pathogen and pest populations. Destruction of this material is accomplished through burning, chipping, burying, and composting.
- Several biological control alternatives are available for insect suppression for strawberry crops including products based on formulated *Bacillus thuringiensis* and insectary-reared predatory mites. Currently, no reliable biological control tactics have been developed for strawberry diseases, although biopesticides, such as Serenade, are available.
- Chemical application of fungicides, insecticides, and miticides may reduce pathogen and pest populations below damage thresholds, but will rarely eradicate them.

Protection: This principle is founded on protection of plants from pathogen infection and pest damage. Practices that protect plants by minimizing factors favoring infection and damage include the following:

- Plant strawberry varieties that are disease resistant or less susceptible to diseases of concern.
- Avoid excessive nitrogen fertilization as many pathogens, insects and mites thrive on succulent tissues.
- Keep fruit from contacting soil by use of mulch under and around the plants.
- Harvest fruit promptly and cool it to protect from fruit rots and insect infestations on overripe fruit.
- Applications of fungicides, insecticides, or miticides may protect susceptible tissues from disease and insect damage.

7.4 Diseases of Primary Concern

Several important diseases that occur in the temperate climate of the northeastern U.S. are described below to help growers manage them with appropriate organic practices.

LEAF BLIGHT Leaf lesions begin as small, circular to irregular, reddish, or purplish spots. As they expand, lesion centers become necrotic and turn light brown with a dark purple halo. Older lesions along major leaf veins develop into large V-shaped lesions that eventually kill the leaf. Heavy leaf infections can inhibit the production of flower buds for the following year, predispose a plant to winter injury, and provide inoculum for infection of the fruit caps. Fruit may also be infected in some instances.

Leaf Blight Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.
Cultural management	Destroying infected leaves at renovation (e.g., mowing and burying) will reduce the amount of carry-over inoculum. Promoting air circulation (plant spacing and weed control) will reduce foliage drying time and limit infection periods.
Chemical treatment	An early season fungicide application is recommended when carry-over inoculum from the previous year is high or conditions are favorable for disease development.

Pesticides Labeled for Management of Leaf Blight					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Nu-Cop 50DF *(copper hydroxide)*	2-3 lbs/acre	1	24	2	Use higher rate when conditions favor disease. Discontinue use if signs of phytotoxicity appear. Copper may cause blue spotting on fruit.
Nu-Cop 50 WP *(copper hydroxide)*	2-3 lbs/acre	1	24	2	Use higher rate when conditions favor disease. Discontinue use if signs of phytotoxicity appear. Copper may cause blue spotting on fruit.
OxiDate *(hydrogen dioxide)*	40-128 fl oz/100 gal water	0	Until spray has dried	4	In fields with a history of disease pressure, use the high rate. Complete coverage is essential.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

LEAF SCORCH Dark purple leaf spots about one eighth to one quarter inch in diameter appear scattered over the upper leaf surfaces or petioles. These spots differ from those of leaf spot in that they are purple throughout (no light centers). Numerous infections can cause a leaf to appear red or light purple and eventually to dry up and appear to have been burned (scorched). Heavy leaf infections can inhibit the production of flower buds for the following year, predispose a plant to winter injury, and provide inoculum for infection of the fruit caps.

Leaf Scorch Management Options	
Scouting/thresholds	None established.
Variety susceptibility	Resistance and tolerance has been reported for several varieties. However, reports from different states are often in conflict with one another; hence resistance/tolerance may be variable and/or region dependent. A consensus of reports suggests that 'Allstar', 'Jewel', 'Canoga', 'Cardinal', 'Cavendish', 'Earliglow', 'Lester', and 'Redchief' have some resistance. 'Tristar' and 'Tribute' are susceptible but tolerant of infection.
Cultural management	Destroying infected leaves at renovation (e.g., mowing and burying) will reduce the amount of carry-over inoculum. Promoting air circulation (plant spacing and weed control) will reduce foliage drying time and limit infection periods.
Chemical treatment	Check with your organic certifier about allowable copper formulations.

LEAF SPOT Initial lesions on leaves begin as small, irregularly shaped purple spots. Mature lesions become approximately one eighth to one quarter inch in diameter, remain relatively round, and the centers of lesions turn from a purplish brown to grayish white. The pathogen primarily infects young, expanding leaves and petioles, and occasionally fruit (black seed). Heavy leaf infections can inhibit the production of flower buds for the following year, predispose a plant to winter injury, and provide inoculum for infection of the fruit caps.

Leaf Spot Management Options	
Scouting/thresholds	None established.
Variety susceptibility	Resistance and tolerance has been reported for several varieties. However, reports from different states are often in conflict with one another; hence resistance/tolerance may be variable and/or region dependent. A consensus of reports suggests that 'Jewel', 'Canoga', 'Cardinal', and 'Lester', have some resistance. 'Tristar' and 'Tribute' are susceptible but tolerant of infection.
Cultural management	Destroying infected leaves at renovation (e.g., mowing and burying) will reduce the amount of carry-over inoculum. Promoting air circulation (plant spacing and weed control) will decrease foliage drying time and limit infection periods.
Chemical treatment	An early season fungicide application is recommended when carry-over inoculum from the previous year is high or conditions are favorable for disease development.

Pesticides Labeled for Management of Leaf Spot

Trade Name[1] (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[2]	Comments
Basic Copper 53 *(copper sulfate)*	2-3 lbs/100 gal	Up to day of harvest	24	2	Copper may cause blue spotting on fruit.
Nu-Cop 50DF *(copper hydroxide)*	2-3 lbs/acre	1	24	2	Use higher rate when conditions favor disease. Discontinue use if signs of phytotoxicity appear. Copper may cause blue spotting on fruit.
Nu-Cop 50 WP *(copper hydroxide)*	2-3 lbs/acre	1	24	2	Use higher rate when conditions favor disease. Discontinue use if signs of phytotoxicity appear. Copper may cause blue spotting on fruit.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

POWDERY MILDEW The edges of infected leaves roll up, sometimes revealing a white, powdery layer of mycelium and spores on the lower leaf surfaces. Purple to reddish blotches also occur frequently on the lower leaf surfaces. Symptoms are usually not evident until middle or late summer. Numerous pepper-like black flecks (overwintering spore-producing structures – cleistothecia) may appear on infected leaf surfaces in fall.

Powdery Mildew Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.. If possible, **avoid** varieties commonly infected in New York which include: 'Guardian', 'Earliglow', 'Darselect', 'Evangeline', 'Annapolis', and to a lesser extent, 'Raritan'.

Powdery Mildew Management Options	
Cultural management	Manage weeds and regulate planting density to promote good air circulation. Avoid excessive nitrogen and sites with poor air drainage.
Chemical treatment	See table below.

Pesticides Labeled for Management of Powdery Mildew					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	4	For best results apply with a spreader/sticker prior to onset of disease. Re-apply at 7-14 day intervals depending on disease pressure and environmental conditions.
JMS Stylet Oil *(paraffinic oil)*	3 qt/100 gal water	-	4	2	A high volume of water is needed for through coverage. Many common pesticides are phytotoxic when applied with or close to oil sprays (e.g., sulfur). Check label for restrictions.
Kaligreen *(potassium bicarbonate)*	2.5-3.0 lbs/acre	1	4	4	Do not mix with highly acidic products or nutrients.
Kumulus DF *(sulfur)*	5-10 lbs/acre	-	24	2	Begin applications when disease first appears. Repeat as necessary.
Milstop *(potassium bicarbonate)*	2.5-5.0 lbs/acre	-	1	4	Do not mix with other pesticides or fertilizers. Not compatible with alkaline solutions.
OxiDate *(hydrogen dioxide)*	40-128 fl oz/100 gal water	0	Until spray has dried	4	Complete coverage is essential. Begin applications when disease first appears. Repeat as necessary.
Thiolux Jet *(sulfur)*	5-10 lbs/acre	-	24	2	Begin applications when disease first appears. Repeat as necessary.

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[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

GRAY MOLD (BOTRYTIS FRUIT ROT) Botrytis fruit rot usually begins as a small lesion at the blossom end or where a berry is touching another infected berry. The infected portion is firm and brown while the berry is still green, but it expands and softens as the fruit ripens. A powdery gray mass of spores covers infected berries if the weather remains humid and/or air circulation is poor.

IPM fact sheet on Gray Mold (Botrytis Fruit Rot) nysipm.cornell.edu/factsheets/berries/botrytis.pdf

Gray Mold (Botrytis Fruit Rot) Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties. Less severely impacted varieties are 'Earliglow', 'Jewel' and 'Clancy'. 'Allstar' and 'Sable' are very susceptible.
Cultural management	Disease control is greatly aided by managing weeds and by using other practices that promote good air circulation and rapid drying of the fruit such as regulating plant density. Spring applications of nitrogen can dramatically increase the potential for infection. Prompt harvest of ripe fruit helps reduce disease development and spread. It may be beneficial to employ an hourly picker to remove only overripe and diseased fruit to prevent infection of clean fruit by other pickers. Overripe fruit should not be consumed. Cull piles should be buried or otherwise physically removed from fields during harvest.
Chemical treatment	Protection of blossoms is critical in gray mold management. Research in New York has consistently shown that excellent gray mold control can be obtained with just two fungicide sprays applied at early bloom and 10 days later. Continued protection of fruit prior to harvest may be necessary during prolonged periods of wet, foggy, or humid weather.

Pesticides Labeled for Management of Gray Mold (Botrytis Fruit Rot)

Trade Name[1] (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[2]	Comments
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	1	Foliar applications: for best results apply with a spreader/sticker prior to onset of disease.
JMS Stylet Oil *(paraffinic oil)*	3 qt/100gal water	-	4	2	When using oil a high volume of water is needed for through coverage. Many common pesticides are phytotoxic when applied with or close to oil sprays. Check the label for restrictions.
OxiDate *(hydrogen dioxide)*	40-128 fl oz/100 gal water	0	Until spray has dried	3	

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[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

ANTHRACNOSE One or more circular spots occur on the fruit. Spots originally are tan or light brown but become darker and sunken. Sunken spots are usually about one eighth to one quarter inch in diameter and may be covered with pink slimy spore masses during wet or very humid periods. The disease may occur on both green and ripe fruit, but is most common on ripe fruit following periods of warm, wet weather. In New York, anthracnose occurs only sporadically and is a more common problem on day-neutral varieties in the summer than it is on June-bearing varieties. However, the disease can be serious on June-bearing varieties if warm, wet weather conditions occur between fruit set and harvest.

Anthracnose Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.
Cultural management	Provide good air circulation by controlling weeds and reducing planting density. The anthracnose fungus is spread throughout a planting by splashing raindrops or sprinkler irrigation. Straw mulch may reduce the rate of disease spread relative to bare ground (less rain splash).
Chemical treatment	See table below.

Pesticides Labeled for Management of Anthracnose

Trade Name[1] (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[2]	Comments
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	2	Foliar applications: for best results apply with a spreader/sticker prior to onset of disease. Re-apply as necessary.
Serenade MAX *(Bacillus subtilis)*	1-3 lbs/acre	0	4	2	Apply on a 7-10 schedule following disease onset.

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[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

LEATHER ROT Infected areas on immature fruit are brown, whereas those on maturing fruit appear bleached out. On all fruit, the infected areas are tough, leathery, and discolored on the inside as well as the outside of the fruit. Diseased fruits have a pungent smell and bitter taste. Leather rot is most severe during periods of abundant warm rains during the fruiting period and in flooded soils. The cultural practices listed in the table below are the most effective control procedures.

IPM fact sheet Leather Rot nysipm.cornell.edu/factsheets/berries/leather_rot.pdf

Leather Rot Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.
Cultural management	Plant only on a well-drained site or provide supplemental drainage. Growing strawberries on raised beds will also reduce disease severity. Minimize soil flooding through site selection; by avoiding planting in ruts; and by preventing or reducing soil compaction. Provide an extra layer of straw mulch between rows throughout the fruiting season. The mulch provides a physical barrier between the soilborn pathogen and the susceptible fruit.
Chemical treatment	See below.

Pesticides Labeled for Management of Leather Rot					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray dries	4	Apply as a soil drench. Since Actinovate AG contains live spores of a microbe, best results will be obtained if used prior to disease onset.

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

RED STELE Red stele is caused by a soilborn aquatic pathogen (Phytophthora) that may persist in the soil for many years even when strawberries are no longer grown. Symptoms of infection often appear just before harvest. Diseased plants appear stunted and off-color, and will often wilt and collapse if the weather becomes warm and dry. Because these same symptoms may be caused by other factors that destroy roots (such as root-feeding insects), the diagnosis depends on an examination of the plant's root system. In a diseased plant, the roots have a "rat-tail" appearance caused by loss of the fine branched feeder roots from the main fleshy roots. The main fleshy roots are rotted from the tips back toward the crown. Cutting or scraping away the white outer portion (epidermis and cortex) just above the rotten areas in early infections sometimes reveals a reddish root core (stele). Infected plants usually appear in groups and are frequently found in the lowest or wettest parts of a field.

IPM fact sheet Red Stele nysipm.cornell.edu/factsheets/berries/red_stele.pdf

Red Stele Management Options	
Scouting/thresholds	None established.
Variety susceptibility	Resistant varieties include 'Earliglow', 'Northeaster',' Mohawk', 'Redchief', 'Guardian', 'Allstar', 'Tribute', 'Tristar', 'Surecrop', and 'Sparkle'. However, these varieties are not resistant to all races of the red stele pathogen (*Phytophthora fragariae*), and as such, the disease could still develop if a race to which they are not resistant is present.
Cultural management	Because the red stele fungus is particularly active in extremely wet soil, plant only on a well-drained site or provide supplemental drainage. Growing strawberries on raised beds will also reduce disease severity.
Chemical treatment	The red stele fungus is not present in every field, thus treatments should be confined to fields and areas within fields where the disease has occurred previously or is suspected.

Pesticides Labeled for Management of Red Stele					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	4	Apply as a soil drench. Since Actinovate AG contains live spores of a microbe, best results will be obtained if used prior to disease onset.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

BLACK ROOT ROT Over time, plant vigor and productivity declines. Feeder rootlets die, and fleshy structural roots deteriorate and become blackened. The blackening starts as patches along the length of the root, rather than from the tip back. This disease is often associated with fields having a long history of strawberry production. Because no single cause of black root rot has been defined, there is no single control.

Black Root Rot Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties. Particularly susceptible varieties are 'Honeoye' and 'Jewel'. These varieties should be avoided in fields without adequate rotation.
Cultural management	Fields with high nematode populations may be more prone to black root rot development. Check nematode populations prior to planting. Cultural practices that reduce soil compaction, improve aeration, and promote good drainage are beneficial for reducing disease. Rotating a field out of strawberries for at least 2 - 3 years before replanting is strongly recommended to minimize black root rot damage. Measures to control red stele will also help alleviate black root rot. Cover crops such as brown mustard and indiangrass and incorporation of compost can also provide disease suppression.
Chemical treatment	See below.

Pesticides Labeled for Management of Black Root Rot					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	4	Apply as a soil drench. Since Actinovate AG contains live spores of a microbe, best results will be obtained if used prior to disease onset.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.5 Other Diseases of Note

ANGULAR LEAF SPOT Minute water-soaked lesions appear first on lower leaf surfaces. These enlarge to form angular spots usually bordered by small veins. When held up to the light spots appear translucent, but are dark green under reflected light. Spots may ooze bacteria under moist conditions, which dry to form a whitish scaly skin. Lesions eventually become visible on upper leaf surfaces as irregular reddish brown spots. Calyxes may also become infected. The disease is favored by day temperature around 68°F, low to near freezing night temperature, and precipitation events such as rain, overhead irrigation or heavy dews.

Pesticides Labeled for Management of Angular Leaf Spot					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
OxiDate *(hydrogen dioxide)*	40-128 fl oz/100 gal water	0	Until spray has dried	4	Complete coverage is essential. Begin applications prior to or when disease first appears. Repeat as necessary.

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

VERTICILLIUM WILT Plants are affected most severely during their first year of growth. Outer leaves turn brown and eventually collapse, but inner leaves remain green until the plant dies. This symptom distinguishes Verticillium wilt from other root and crown disorders. Affected plants may occur uniformly, but more typically, they appear scattered throughout a field. In problem areas or after the last crop of tomatoes, potatoes, or eggplant, plant only varieties resistant to Verticillium wilt for at least 3 years. Resistant varieties include 'Earliglow', 'Guardian', 'Allstar', 'Tribute', and 'Tristar'. Many weeds are hosts of the Verticillium fungus, particularly nightshade, groundcherry, redroot pigweed, lambsquarters, and horsenettle. These weeds should be strictly controlled in current and future planting sites to keep *Verticillium* inoculum low.

Pesticides Labeled for Management of Verticillium Wilt					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Actinovate-AG *(Streptomyces lydicus)*	3-12 oz/acre	0	1 hr or until spray has dried	4	Apply as a soil drench. Since Actinovate AG contains live spores of a microbe, best results will be obtained if used prior to disease onset.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.6 Insects and Mites of Primary Concern

The insects and mites that are considered major pests in strawberries can vary in occurrence both from year to year and from site to site. For these reasons it is important to be familiar with the life cycle of the pest to assist in developing a scouting program that will ensure a pest problem can be discovered and dealt with before it becomes an outbreak. Alternatively, it is important to know when a potential pest is not causing significant economic damage so that unnecessary controls can be avoided. Applying an organically approved broad-spectrum insecticide such as PyGanic EC (a pyrethrum) when not necessary, for example, is not only a waste of money but also has the potential to disrupt biological control by beneficial organisms. This illustrates the need to take potential biological control agents (predators, parasitoids, parasites, microbes) into account when making management decisions. Following are descriptions of the most commonly found insect pests in strawberry plantings.

ROOT WEEVIL Different species, but most commonly the strawberry root weevil, the black vine weevil, and the rough strawberry root weevil. These pests attack the roots or crowns of plants while in the grub stage. All have a one-year life cycle, although some are known to live two seasons. Adults emerge about late June. Beds with heavy infestations show distinct patches or spots that appear stunted and have substantially reduced yields. The roots of injured plants are badly eaten away, and continued infestation may destroy infested plants.

IPM fact sheet Root Weevil nysipm.cornell.edu/factsheets/berries/root_weevils.pdf

Root Weevil Management Options	
Scouting/thresholds	None established.
Variety susceptibility	None adapted to the Northeastern region.
Cultural management	Rotate out of strawberries for a least 1 year to reduce root weevil density. A barrier (plastic fence) can prevent adults from moving from an infested field to a new field to be planted. See www.omafra.gov.on.ca/english/crops/hort/news /allontario/ao0306a2.htm for details.
Biological control	Two species of *Heterorhabditis*, insect parasitic nematodes, *H. bacteriophora* and *H. marelatus*, can provide control of larvae. Release nematodes either in spring when soils warm (>50 F) or in late summer - early fall. Provide sufficient water to move nematodes into the root zone. For sources visit www2.oardc.ohio-state.edu/nematodes/ nematode_suppliers.htm.
Chemical treatment	None known.

SAP BEETLE Sap beetle adults make cavities in ripe and overripe fruit as well as spread spores of decay organisms. The larvae also feed on ripe and overripe fruit and are a source of contamination in harvested fruit. Until a few years ago, sap beetles were uncommon in strawberries. Now, sap beetles are occasionally found in high numbers in later ripening strawberry plantings throughout the state. Two species feed on strawberry fruits: the common picnic beetle, one quarter inch long with four yellow spots on the back, and the smaller, brown strawberry sap beetle without distinctive markings. Strawberry sap beetle is the more serious pest because it does not limit its activity to over-ripe fruit. Beetles overwinter at the edge of woodlots and possibly under other perennial fruit crops, such as brambles and blueberries, but they do not appear to overwinter in strawberry fields. As strawberries ripen, beetles move into the field and begin feeding and laying eggs. Fruit touching the ground or straw mulch appears particularly vulnerable.

IPM fact sheet Sap Beetle nysipm.cornell.edu/factsheets/berries/ssb.pdf

Sap Beetle Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties, although cultivars that tend to hold fruit off the ground may be less vulnerable to adult feeding and larval contamination.
Cultural management	Keep the field free of ripe and over-ripe fruit.
Chemical treatment	None known.

TARNISHED PLANT BUG This pest causes "cat faced" or "button" berries. It damages the fruit by feeding on the developing fruit. The fruit tissue in the immediate area of damaged seeds stops developing. Little information is available on cultivar differences in susceptibility to tarnished plant bug, but early maturity is correlated with freedom from injury; later cultivars may suffer more damage. Also, highly productive cultivars appear to tolerate feeding damage better than less productive ones. Tarnished plant bug feeds on many crop and non crop plants as they flower and fruit. Hence, weedy fields can promote higher populations.

IPM fact sheet Tarnished Plant Bug nysipm.cornell.edu/factsheets/berries/tpb.pdf

Tarnished Plant Bug Management Options	
Scouting/thresholds	Anytime from just before the blossoms open until harvest, check for tarnished plant bug nymphs by striking the plant over a flat, low-sided, light-colored dish. Suggested action threshold: 0.5 nymphs per cluster, or 4 out of 15 clusters with 1 or more nymphs.
Variety susceptibility	'Honeoye' and other highly productive cultivars appear less susceptible to feeding injury. Early-flowering cultivars may be less susceptible to injury also. Day-neutral varieties are particularly vulnerable later in the season.
Cultural management	Row covers accelerate plant development and help avoid injury. Pressure is often highest in weedy fields or in fields bordered by woody shrubs.
Chemical treatment	See below.

Pesticides Labeled for Management of Tarnished Plant Bug					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Short residual activity may require multiple applications. Caution: do not use when bees are active in the planting.

Pesticides Labeled for Management of Tarnished Plant Bug					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
PyGanic 5.0 EC_{II} *(pyrethrin)*	4.5-18.0 fl oz/acre	0	12	4	Short residual activity may require multiple applications. Caution: do not use when bees are active in the planting.

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[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

TWOSPOTTED SPIDER MITE In early spring, mites begin feeding on the undersides of new leaves, sometimes resulting in small yellow spots on the upper leaf surfaces. These symptoms do not occur in all cases, however, and are not seen later in the year. Brownish dry areas on the lower leaf surfaces are more characteristic of damage. Later, the entire lower leaf may become dry and brown, giving it a bronzed appearance. Heavily infested plants look dry and stunted, and their sparse new growth is yellowish and distorted. Damage is first seen and is most prevalent in dry areas of a field. Mild growing areas in New York (Hudson Valley and Long Island) experience problems with mites most frequently.

Twospotted Spider Mite Management Options	
Scouting/thresholds	Five mites/leaf or 15 out of 60 mature (fully expanded) leaflets infested with 1 or more mites. Regular leaf monitoring is necessary for assessing population growth.
Variety susceptibility	No known resistant varieties.
Cultural management	Ensure plots are not over fertilized. Provide adequate irrigation. Cool, moist conditions are unfavorable to mites. Do not use other insecticides that kill predatory mites. Mow and incorporate leaves at renovation.
Chemical treatment	Chemical control of spider mites is often not completely effective because of their high mobility, tendency to reside on the underside of leaves where it is difficult to reach with miticides, high reproductive rate, and resistance to some pesticides. Good coverage of the plants, particularly the undersides of the leaves, is critical for adequate protection. Use adequate water (200 - 300 gal/A) for maximum effectiveness of the miticide. Repeat at 7- to 10-day intervals as necessary unless otherwise noted on label. Soap sprays may provide some control but excellent coverage is essential, especially on lower leaf surfaces.

Pesticides Labeled for Management of Twospotted Spider Mite					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
JMS Stylet Oil *(paraffinic oil)*	3 qt/100 gal	-	4	1	Apply for optimum coverage of leaf surfaces. Use high pressure, small droplet size, and adequate gallonage to ensure good coverage.

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.7 Minor and Sporadic Insect and Mite Pests

Many insects found in strawberry plantings of New York, while having the capacity to cause economic damage, do not occur on a yearly basis at damaging levels and therefore are considered minor or sporadic pests. For these reasons it is important to be familiar with the life cycle of the pest to assist in developing a scouting program that will ensure a pest problem can be discovered and dealt with before it becomes an outbreak. And again, it is important to know when a potential pest is not causing significant economic damage so that unnecessary controls can be avoided.

BUD WEEVIL (CLIPPER) Adults puncture blossom buds while feeding in the spring, deposit eggs in the nearly mature buds, and then girdle the bud so that it hangs by a mere thread or falls to the ground. Injury is most likely along edges of fields or when strawberries are grown next to woodlots or other sites suitable for adult hibernation. Frequent scouting for bud cutting is important in areas where weevil pressure is expected to be high. In the past, a treatment threshold of 1 cut bud per linear foot has been recommended. Research conducted in the last few years, however, suggests that plants can sustain many times this pressure without a measurable reduction in yield if clipping occurs on tertiary flower buds. The new threshold is more than one primary or secondary flower bud or more than two tertiary flower buds per truss, or more than one injured truss per foot of row. Mulches and full-canopy beds may encourage newly emerged adults to remain in the planting so that damage increases in succeeding years. Using cropping systems shorter than 3 years, plowing under all old beds immediately after final harvest, and removing foliage and mulch to reduce the suitability of overwintering sites help lessen the chances of clipper injury.

IPM fact sheet Bud Weevil (Clipper) nysipm.cornell.edu/factsheets/berries/strawberry_clipper.pdf

SPITTLEBUG White frothy masses on the stems and leaves around the time of bloom harbor the nymphs, which pierce the stems and suck plant juices. Their feeding, if extensive, can stunt the plants and reduce berry size. Leaves appear crinkled and darker green than undamaged leaves. The spittle masses are a great nuisance to pickers. Threshold is one mass per square ft of row. Good weed control may help to reduce numbers. Populations are usually largest in weedy fields. Only one generation is produced per year. The leaves recover after the insects are gone.

IPM fact sheet Spittlebug nysipm.cornell.edu/factsheets/berries/meadow_spittlebug.pdf

STRAWBERRY ROOTWORM Grubs feed on roots in late spring to early summer. Adults feed on leaves in May and again in late July, at night.

Pesticides Labeled for Management of Strawberry Rootworm					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.
PyGanic 5.0 EC_{II} *(pyrethrin)*	4.5-18.0 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

GREENHOUSE WHITEFLY Small, white insects that resemble flies but are actually more closely related to aphids. Whiteflies feed on young plants, causing stunting.

CYCLAMEN MITE This tiny (one one-hundredth-inch) mite is pinkish orange and shiny when mature. Its translucent eggs are often so abundant that they appear as a white mass along the mid-veins of folded, newly emerging leaves. The mites feed on the young leaves in plant crowns; when the leaves emerge, they are stunted, crinkled, and malformed. Blossom feeding later results in misshapen fruit. The mites are most troublesome in strawberry beds that are kept for long periods. They increase in number during bloom and peak during fruit development. Avoid infested planting stock. 'Cabot' is particularly susceptible.

LEAFROLLER Several species of moth larvae roll or fold strawberry leaves with silk. Leaf injury can be seen throughout the season, but an extremely large population is required before noticeable crop damage occurs.

Pesticides Labeled for Management of Leafroller					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Dipel DF *(Bacillus thuringiensis)*	0.5-1.0 lbs/acre	0	4	1	See label for specific leafroller species product can be used against.
Entrust Naturalyte *(spinosad)*	1.25-2.0 oz./acre	1	4	1	Treat when pests appear, targeting eggs at hatch or small lavae.
Javelin WG *(Bacillus thuringiensis)*	0.5-1.0 lbs.acre	0	4	1	See label for specific leafroller species product can be used against.
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.
PyGanic 5.0 EC_{II} *(pyrethrin)*	4.5-18.0 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

APHIDS These soft-bodied insects usually occur on new shoots and buds in the crown of the plant and along the veins on the undersides of the leaves. When present in large numbers, they weaken the plant. Their honeydew promotes the growth of a black sooty mold, which makes the fruit and leaves sticky, hindering harvest and reducing marketability. More important, aphids are vectors for several serious virus diseases. Aphid populations often are controlled by natural enemies and do not require insecticide control.

Pesticides Labeled for Management of Aphids					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
M-Pede *(insecticidal soap)*	1-2% v/v	0	12	4	Works by contact. Good coverage is important.
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

POTATO LEAFHOPPER Adults migrate into New York state in early to mid June, carried by summer weather fronts. The adults and nymphs feed along the veins on the undersides of leaves by sucking plant juices, and in the process, inject a toxic substance with their saliva. Affected plants have shortened petioles and small distorted leaves that bend down at right angles. Leaf yellowing is also seen, starting at the margins and progressing toward the mid-vein. Avoid proximity to alfalfa plantings, which provide a major source of potato leafhopper population build-up.

Pesticides Labeled for Management of Potato Leafhopper					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.
PyGanic 5.0 EC_{II} *(pyrethrin)*	4.5-18.0 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

JAPANESE BEETLE Beetles emerge in early July and feed on leaves. Although there are Japanese beetle traps, research has shown that the traps may attract more beetles into a planting than they eliminate in the traps.

Pesticides Labeled for Management of Japanese Beetle					
Trade Name[1] (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[2]**	**Comments**
Aza-Direct *(azadiractin)*	1-2 pts/A	0	4	4	Is reported to have some repellent activity for beetles.
PyGanic 1.4 EC_{II} *(pyrethrin)*	16-64 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.
PyGanic 5.0 EC_{II} *(pyrethrin)*	4.5-18.0 fl oz/acre	0	12	4	Spraying should begin when the insects first appear. Repeat as required. Caution: do not use when bees are active in the planting.

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.8 Slug Management

These soft-bodied mollusks resemble snails without a shell. Slugs feed on ripening fruit, leaving holes in the berries. They are most active at night and during cool, wet weather. Populations are greatest when the weather is damp and the planting is mulched. Translucent silver to whitish slime trails are visible on damaged plant parts.

IPM fact sheet Banded Slug nysipm.cornell.edu/factsheets/fieldcrops/b_slug.pdf
IPM fact sheet Gray Garden Slug nysipm.cornell.edu/factsheets/fieldcrops/gg_slug.pdf
IPM fact sheet Marsh Slug nysipm.cornell.edu/factsheets/fieldcrops/m_slug.pdf
IPM fact sheet Spotted Garden Slug nysipm.cornell.edu/factsheets/fieldcrops/sg_slug.pdf

Slug Management Options	
Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.
Cultural management	Eliminating mulch will reduce slug populations, but will cause other problems, so this is not recommended. Good sanitation and weed control helps to reduce slug populations. In areas where slugs are a problem, avoid perennial clovers as cover crops and rotate out of alfalfa or other perennial legumes 1 year prior to planting establishment. Overhead irrigation creates conditions especially favorable to slugs. If overhead irrigation must be used, irrigate during morning hours to allow foliage to dry before evening.
Chemical treatment	See below.

Pesticides Labeled for Management of Slugs

Trade Name[1] (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[2]	Comments
Sluggo AG *(iron phosphate)*	20-44 lbs/acre	0	0	4	Spread bait around perimeter to intercept slugs migrating toward berries.

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

[2] Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, 4-no data found.

7.9 Wildlife Management

Various rodents can damage a strawberry planting, especially as they feed under mulch in the winter. Closely mowing the area around the planting in early November will reduce the habitat for voles and mice. The habitats (woodlots) of predators that feed on rodents (hawks, owls, foxes) should be protected around the area. A number of poisonous baits are labeled for use in agricultural areas. To be most effective, baits should be placed in feeding stations that exclude large animals and are replenished throughout the winter.

Deer browsing can devastate berry plantings. Multiple strategies are required to discourage deer from feeding on berry plantings. Refer to *Reducing Deer Damage to Home Gardens and Landscape Plantings* by P. Curtis and M. Richmond for recommended methods.

When using dogs and invisible fence to manage vertebrate pests in a planting, there is food safety risk associated with the dog excrement. If the dog consistently uses an area away from the field, the risk is somewhat reduced. Also, if the dog prevents other vertebrate animals from using the field, that is also a food safety risk reduction. Using dogs primarily in the winter and early spring when deer browsing is greatest (and avoiding use during harvest) will also minimize food safety risk.

Plantskydd repellent, www.plantskydd.com, is an OMRI-approved product that is registered for use in New York and may provide benefit by repelling deer from strawberry plantings.

Table 7.2. Vertebrate Damage Mitigation Practices	
Animal Pest	**Management Practices**[1]
Mice and voles	Removal of dropped fruit; habitat manipulations including elimination of unmowable areas surrounding plantings; monitor to determine the need for management. Mow closely in late fall around the planting and apply winter mulch only after mowing. Population control through trapping by landowner.
Raccoons	Avoid sites with woods along the edge(s) because these will support raccoon populations. Electrified exclusion fencing. Population reduction through shooting by licensed hunters or landowners in appropriate seasons; through trapping by landowner, by licensed trapper, or by licensed nuisance wildlife control agent.
Red and gray foxes	Tend to chew on irrigation lines. Manipulation including elimination of protective cover around plantings. Population reduction through shooting by licensed hunters or landowners in appropriate seasons; through trapping by landowner, by licensed trapper, or by licensed nuisance wildlife control agent.
White-tailed deer	Exclusion fencing (8 ft. [250 cm] high-tensile woven wire or 5 to 6 ft. [150 to 200 cm] electric exclusion fencing; peanut-butter baited electric fences; invisible fencing with dogs); habitat manipulation including elimination of protective cover around plantings. Population reduction through shooting by licensed hunters, landowners or their agents with DMAP or nuisance deer permits. Unlike with other vertebrate pests, landowners cannot kill nuisance deer without a permit.
Woodchucks	Exclusion fencing (electrified exclusion fencing); habitat manipulation including removal of brush piles. Population reduction through shooting by licensed hunters or landowners; through trapping by landowner or by licensed nuisance wildlife control agent.

[1] Conduct shooting and trapping only as defined by New York State Department of Environmental Conservation regulations. Shooting for nuisance wildlife control is allowed only when neighboring occupied buildings are >500 ft. distant; shooting when neighboring buildings are less than 500 ft. distant requires neighbor permission. Shooting also may require a permit, depending on animal and season. Also check local ordinances, as shooting and trapping are prohibited in some areas. Note: It is illegal to trap a nuisance animal and release it onto public lands or someone else's property. It must be released on the landowner's property or killed.

7.10 Considerations During Harvest and Renovation

During harvest operations some pests can become a nuisance, e.g. wasps and yellow jackets, particularly in U-pick operations. Wasp and yellow jacket nests can be destroyed during the growing season as they are found in the planting and surrounding areas. Some species are ground-nesting and such nests can be destroyed by drenching with hot water. Traps baited with sugary liquids, such as Hi-C, provide a means of reducing the population of wasps and yellow jackets, but the effectiveness of this tactic is unknown.

During harvest much can be done to reduce disease and insect pressure by eliminating infested and infected fruit from the planting. Separate damaged fruit from healthy fruit as it is being picked. Designate pickers to cull such fruit from the field at harvest time. Then bury or burn the diseased and infested fruit. This is helpful to combat gray mold, leather rot and anthracnose (through the removal of overripe and infected fruit), strawberry sap beetle (through the removal of overripe or infested fruit), and slugs (through the removal of overripe and dropped fruit).

After harvest, a post-harvest grading table will provide an excellent opportunity to grade out damaged, diseased and infected fruit which will lower quality and market value. All culled fruit should be destroyed by burning or burying. Cleanliness or sanitation in the planting is very important, removing dropped berries during harvest will reduce risk from gray mold, leather rot and anthracnose, strawberry sap beetle and slugs, as described above. At this time also make note of trouble spots in the field, or the presence of unthrifty plants, foliar diseases, leaf damage, etc. and plan steps to maintain a healthy planting.

At renovation do a thorough job of mowing off the plants, chopping mulch, and turning under infected and infested plant parts. Application of a thick mat of straw after plants regrow will provide protection for the winter and assist in protecting plants from rain splashed inoculum from buried plant debris.

Keep in mind your production goals and recognize that it should be possible to obtain good yields in organic strawberry production. Therefore, maintain good records of the planting condition, pest pressure, amount harvested and know your markets.

8. SMALL-SCALE SPRAYER TECHNOLOGY

8.1 Spraying Small Strawberry Plantings

On many small-scale strawberry plantings, spraying often requires special attention to calibration, calculating amounts of pesticide to use, and measuring pesticide products.

To ensure even distribution throughout the canopy, a systematic approach to spraying the whole canopy is essential. Take particular care to cover the top of the canopy as well as ensuring adequate penetration into the inside and middle of the canopy and the fruiting zone. Water sensitive cards (Syngenta) or Surround, kaolin clay, (Engelhard) may be used as tracers to monitor spray distribution.

PRIOR TO SPRAYING—CALIBRATING SPRAYERS

• ***Calibration of backpack sprayers***

Use clean water

DYNAMIC CALIBRATION

1. Select correct nozzle and pressure.
2. Measure and mark off an area 10 feet x 10 feet on concrete.
3. Fill sprayer to a known level, mark the fill level.
4. Spray the area on the concrete.
5. Refill sprayer to the fill mark.
6. Compare quantity collected with nozzle chart and desired amount.

STATIC CALIBRATION

1. Select correct nozzle and pressure.
2. Measure and mark off an area 10 feet x 10 feet on concrete.
3. Spray the area and record time taken.
4. Carry out stationary run of same time duration, catching liquid in a graduated measuring jug.
5. Compare quantity collected with nozzle chart and desired amount.

CALCULATING THE AMOUNT OF PESTICIDE TO USE

Some organically approved pesticides are typically sold for large-scale plantings and give application rates on a per acre basis. When converting a known quantity per acre to spray a smaller area, the first step is to measure the area to be sprayed using a tape measure. Divide the number of square feet you have measured by 43,560 to obtain the acreage (in decimal form).

Example:

1. If you are going to spray 20,000 sq. ft,
   20,000 divided by 43,560 = 0.459 acre
2. The label states 3 pints of product per acre
   Multiply the label rate per acre by the decimal for you area
   3 pints multiplied by 0.459 = 1.38 pints
3. Remember there are 16 fl oz in 1 pint.

MEASURING SMALL AMOUNTS OF PESTICIDE

The following tables and examples provide information on converting pesticide rate amounts for smaller areas.

Table 8.1. How much powder or granules should I use?

Volume of liquid	*100 gallons*	*25 gallons*	*5 gallons*	*1 gallon*
Amount of powder or granules to use	4 oz	1 oz	$^3/_{16}$ oz	½ tsp
	8 oz	2 oz	$^3/_8$ oz	1 tsp
	1 lb	4 oz	$^7/_8$ oz	2 tsp
	2 lb	8 oz	1 ¾ oz	4 tsp
	3 lb	12 oz	2 $^3/_8$ oz	2 Tbsp
	4 lb	1 lb	3 ¼ oz	2 Tbsp + 2 tsp

• ***Powders and granules***

Example: The label states 3 lbs of powdered product per 100 gallons but you only wish to use a backpack sprayer with a 5-gallon tank. Table 8.1 shows you need to mix in $2^3/_8$ oz of powder. Use clean weighing scales to provide the correct amount of powder, NEVER use a volumetric measure, e.g. a measuring cup, because the bulk density of different products varies.

Table 8.2. How much liquid should I use?				
Volume of liquid	*100 gallons*	*25 gallons*	*5 gallons*	*1 gallon*
Amount of liquid to use	1 gal	2 pts	6 ½ oz	1 ¼ oz
	4 pts	1 pt	3 ¼ oz	$^{5}/_{8}$ oz
	2 pts	½ pt	1 $^{9}/_{16}$ oz	$^{5}/_{16}$ oz
	1 ½ pt	6 oz	1 ¼ oz	¼ oz
	1 pt	4 oz	$^{7}/_{8}$ oz	$^{3}/_{16}$ oz
	8 oz	2 oz	$^{7}/_{16}$ oz	½ tsp
	4 oz	1 oz	¼ oz	¼ tsp

• ***Liquids***
Example: The label states 4 pts of a liquid product per 100 gallons of spray but you only wish to use a backpack sprayer with a 5-gallon tank. Table 8.2, below, shows you need to mix in 3¼ fl oz of liquid product. Use a clean measuring cylinder or vessel to provide the correct amount of liquid.

Table 8.3. Dilution of liquid products to various concentrations			
Dilution rate	*1 gallon*	*3 gallon*	*5 gallon*
1 in 100	2 Tbsp + 2 tsp	½ cup	¾ cup + 5 tsp
1 in 200	4 tsp	¼ cup	6 ½ Tbsp
1 in 800	1 tsp	1 Tbsp	1 Tbsp + 2 tsp
1 in 1000	¾ tsp	2 ½ tsp	1 Tbsp + 1 tsp

• ***Measuring equipment.***
Always use measuring equipment that is dedicated only for pesticide use. For very small quantities of liquids, a syringe can be useful. For powder or granular products use weighing scales, do not rely on a measuring cup as the bulk density of products varies.

• ***Safety.*** Be sure to wear the proper protective clothing and equipment as required on the pesticide label. Always be aware of watercourses, neighboring properties and changes in the weather.

8.2 Selecting a Small Sprayer for the Small, Organic Strawberry Planting

There are many important points to consider before purchasing a sprayer, not the least of which is the area to spray, the proximity of the local supplier, standard of manufacture, etc. There are many growers with small plantings who need spraying equipment ranging from backpack sprayers to small truck- or ATV-mounted machines.

CANOPY SPRAYERS

Backpack sprayers

Small capacity (4-5 gallon) sprayers will produce up to approximately 100 psi pressure. Weight is an important consideration and growers should select a sprayer with good, wide, padded straps to ease the load on your shoulders. Correct nozzle selection according to the target is very important to ensure even coverage. A good-sized filling hole at the top is also important.

There are three factors affecting application rate - forward speed, pressure, and nozzle tip size. Unfortunately most inexpensive backpack sprayers have no pressure gauge. Pay more money and purchase a backpack sprayer with a pressure gauge or, better still, purchase a spray management valve as standard or as an option. Normally output increases or decreases according to the pressure in the system, (which is dependent upon how vigorous you are in pumping the handle up and down). A spray management valve, such as a CF valve, will ensure a constant output irrespective of hand pump action. The CF valve evens out fluctuations in pressure, e.g. will only allow a maximum and minimum pressure thus ensuring even flow. The Fountainhead Group sells a backpack sprayer with a simple valve which ensures the correct pressure is not exceeded.

An alternative to the hand-operated backpack sprayer is an electrically-operated backpack sprayer, which utilizes a small rechargeable battery. Maximum pressure is relatively low and it is easier than using a traditional hand pump system, particularly if you have many rows of plants to spray. Similarly a small back pack sprayer fitted with a small gas engine is available. The electric version is quieter to use, but you must remember to recharge the batteries otherwise spraying will be delayed.

Portable mist and air blower backpacks

These are ideal where canopy penetration is required, e.g. denser, vigorous plantings. A small gas engine drives a fan blower which creates an airstream which passes along a hand-held tube (similar to a leaf blower). The tube has a nozzle situated at the end so that liquid spray can be squirted into the airstream. The operator directs the spray cloud towards the canopy by pointing the hand-held tube. It is preferable to point the tube backwards to avoid walking into the spray cloud. Engine speed can be reduced which enables a slower airspeed to match a smaller canopy in early season. They are very good at rustling the canopy and getting good penetration and deposition. They are heavy! Noise is a problem, so ear protection must be worn.

Portable engine-driven gas sprayers
If weight is a problem, and ground conditions are relatively smooth, a number of manufacturers offer a sprayer with a small gas engine and a 10 to 12 gallon tank. Larger capacity tanks (14 to 100 gallons) are often trailed and can be pulled by a lawn tractor, ATV, Gator, or small tractor.

Small, mounted sprayers
Ideal for mounting onto the carrier rack of an ATV, 15 to 25 gallons, they use a small electric pump to provide up to 70 psi. When used with a hand wand and a hose, they can be used to spray short rows. The same system is ideal for weed control and spot spraying of weeds.

Large, skid mounted sprayers
Ideal for fitting into the back of a pick-up truck, these sprayers have a tank capacity of 35 to 200 gallons, and an electric-start gas engine.

HERBICIDE OR GROUND APPLICATION SPRAYERS
Backpack, small ATV-mounted tank, and hand-lance sprayers
These sprayers can be used for herbicide application **BUT** be very careful that there is no carry-over from herbicide residues in the sprayer, therefore wash them out very thoroughly before using them to apply materials other than herbicides. Alternatively, have dedicated herbicide-only equipment.

Controlled Droplet Applicators (CDA)
The use of CDA's will considerably reduce the need to carry vast amounts of water. A spinning disc (battery powered) will produce 95% of the same-size droplets, thus reducing herbicide rates by at least 50% and water rates by 75%. Herbi and Mantis (trade names) are both hand-held CDA sprayers. ATV- or tractor-mounted shielded CDA sprayers such as the Environmist also reduce spray rates while shielding the plants from the spray.

Wick wipers
Where occasional weeds and access over wet land are a problem, the use of a hand-held wick wiper is an easy-to use, effective option. A small tank, usually contained in the handle, holds the liquid, which soaks a rope wick or a sponge. The rope or sponge can then be wiped against the weeds.

For further information on pesticide application technology visit www.nysaes.cornell.edu/ent/faculty/landers/pestapp.

9. PESTICIDES MENTIONED IN THIS PUBLICATION

Table 9.1 Fungicides and Bactericides

Trade Name	Active Ingredient	EPA Reg. No.
Actinovate-AG	*Streptomyces lydicus*	73314-1
Basic Copper 53	copper sulfate	45002-8
Kaligreen	potassium bicarbonate	11581-2
Kumulus DF	sulfur	51036-352
Milstop	potassium bicarbonate	70870-1-68539
NuCop 50 WP	copper hydroxide	45002-7
NuCop 50 DF	copper hydroxide	45002-4
Organic JMS Stylet Oil	paraffinic oil	65564-1
OxiDate	hydrogen dioxide	70299-2
Serenade MAX	*Bacillus subtilis*	69592-11
Thiolux Jet	sulfur	100-1138

Table 9.2. Insecticides and Miticides		
Trade Name	**Active Ingredient**	**EPA Reg. No.**
Aza-Direct	azadiractin	71908-1-10163
Dipel DF	*Bacillus thuringiensis*	73049-36
Entrust Naturalyte	spinosad	62719-282
Javelin WG	*Bacillus thuringiensis*	70051-66
M-Pede	potassium salts of fatty acids	62719-515
Organic JMS Stylet Oil	paraffinic oil	65564-1
PyGanic EC 1.4 II	pyrethrins	1021-1771
PyGanic EC 5.0 II	pyrethrins	1021-1772

Table 9.3. Herbicides		
Trade Name	**Active Ingredient**	**EPA Reg. No.**
GreenMatch	citrus extract (d-limonene)	82052-4
Matran EC	clove oil	exempt from registration

Table 9.4. Mollusk Control Chemicals		
Trade Name	**Active Ingredient**	**EPA Reg. No.**
Sluggo-AG	iron phosphate	67702-3-54705

9.1 Pesticides Labeled for use in Organic Strawberry Production

At the time the guide was released, the pesticides listed in this guide were allowable for organic production under the National Organic Program Rule and registered for use in New York. The authors relied mainly on the Organic Materials Review Institute OMRI list for pesticides to include. Always check with your certifier before using any new pesticide.

Given the high cost of many pesticides and the limited efficacy data available for many of them, the importance of developing an integrated approach based on cultural practices for disease and insect management, as described in the previous section, cannot be emphasized strongly enough. **Pesticides should not be relied on as a primary method of pest control**. Scouting, forecasting, or trapping pests are important for detecting infestations at an early stage. When conditions do warrant an application, proper choice of materials, proper timing, and excellent spray coverage are essential.

9.2 Pesticide Regulatory Considerations

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

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

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

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

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

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

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

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

9.3 Optimizing Pesticide Effectiveness

Information on the effectiveness of a particular pesticide against a given pest can sometimes be difficult to find. Some university researchers include pesticides approved for organic production in their trials; some manufacturers provide trial results on their web sites; some farmers have conducted trials on their own. Efficacy ratings for pesticides listed in this guide were summarized from university trials and are only provided for some products.

In general, pesticides allowed for organic production may kill a smaller percentage of the pest population, could have a shorter residual, and may be quickly broken down in the environment. Read the pesticide label carefully to determine if water pH or hardness will negatively impact the pesticide's effectiveness. Use of a surfactant may improve organic pesticide performance. OMRI lists adjuvants in OMRI Products List, Web Edition – Crop Products, www.omri.org/crops_category.pdf. Regular scouting and accurate pest identification are essential for effective pest management. Thresholds used for conventional production may not be useful for organic systems because of the typically lower percent mortality and shorter residual of pesticides allowed for organic production. When pesticides are needed, it is important to target the most vulnerable stages of the pest. Thoroughly cover plant surfaces, especially in the case of insecticides, since many must be ingested to be effective. The use of pheromone traps or other monitoring or prediction techniques can provide an early warning for pest problems, and help effectively focus scouting efforts.

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11. GLOSSARY

(Adapted from: Wikipedia, www.wikipedia.org/, the free online encyclopedia)

Adjuvant – any substance added to the spray tank, (separate from the pesticide) that will improve the performance of the pesticides, (herbicides, insecticides, miticides, fungicides, bactericides), fertilizers etc. by reducing the surface tension of the water and improving spread and coverage.

Agroecosystem – all of the living and non-living components, including inputs and outputs, that comprise a spatial and functional coherent unit of agricultural activity.

Allelopathy – condition in which one plant emits substances that affect germination, development or growth of other plants in contact with the substance.

Annual – a plant that completes its life cycle within one year (germination, flowering, seed production, death).

Biennial – a flowering plant that takes two years to complete its biological life cycle.

Buffer zone – a physical space of sufficient size that separates two or more areas of activity so that these areas do not affect each other.

Cation exchange capacity – (CEC) is the capacity of a soil to retain and substitute cations (positively charged ions, e.g. potassium) between the soil and the soil solution. CEC is a measure of nutrient retention capacity.

Compost – a combination of plant, animal and other organic materials that have been decomposed largely through aerobic processes into a substance rich in carbon, nutrients, and biological activity.

Crop rotation – the practice of growing, in the same area, in sequential seasons, a series of dissimilar types of crops to avoid the build up of pathogens and pests that often occurs when one species is continuously cropped.

Frost pocket – an area where still air, cooled by ground-level radiation, travels downhill, replaces warm air, and accumulates to form pockets of very cold air in depressions, valleys, and hollows.

Green manure – a type of cover crop grown for a specific period of time, then incorporated into the soil to add nutrients and organic matter for soil improvement.

Humus – organic matter that is well-decomposed, stable, and contributes to soil tilth and cation exchange.

Immobilization – is when organic matter decomposes and is absorbed by micro-organisms, therefore preventing it being accessible to plants for periods of time. Immobilization is the opposite of mineralization.

Integrated Pest Management (IPM) – a management strategy aimed at insects, mites, plant diseases, weeds, and other pests that uses a variety of planned, complementary tactics including: mechanical devices, physical devices, genetic resistance, biological control, cultural practices, and chemical treatment. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level.

Macroclimate – refers to the regional climate of a broad agricultural area. It can include an area on the scale of tens to hundreds of kilometers.

Mesoclimate – refers to the climate of a particular planting site and is generally restricted to a space of tens or hundreds of meters.

Microclimate – refers to the specific environment in a small restricted space such as a row of plants or corner of a field.

Mineralization – refers to the process where an organic substance is converted to an inorganic substance that can be taken up by the plant.

Nitrogen assimilation – process by which plants expend energy to take up nitrate and ammonium ions and incorporate them into organic molecules required for growth.

Nitrogen budget – accounting that quantifies the nutrients entering the farm (e.g. fertilizers, manure, legumes crops, soil residual nitrogen) and the nutrients leaving the farm (crop harvest, runoff, leaching, volatilization) for the purpose of balancing inputs and exports.

Nitrogen fixation – the biological process by which nitrogen gas (N_2) in the atmosphere is converted into ammonium compounds that are used by plants.

Organic certification – a certification process for producers of organic food and products that requires strict adherence to production standards for growing, storing, processing, packaging and shipping.

Perched water table – accumulated water above the level of the local water table because impermeable rock or sediment prevents downward movement of water into the local water table.

Perennial –a plant that completes its life cycle (germination, flowering, seed production) over more than one year.

Summer annual – an annual plant that germinates, flowers, produces seed and dies within the same growing season.

Surfactant – (or wetting agent) a soap-like adjuvant added to water or some other liquid to increase wetting properties by reducing the surface tension of the droplets.

Threshold – the density of a pest (insect, mite, plant disease, weed, etc.) at which a control treatment will provide an economic return.

Tilth – a term describing soil that is friable, crumbly, and not compacted which allows rainfall to penetrate and roots to grow without obstruction.

Wind break – (or shelterbelt) is a planting around the edge of a field consisting of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion.

Winter annual – a plant that germinates in the fall or winter, then flowers, produces seed and dies within one year.