2025
Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production

Cornell Cooperative Extension

These guidelines are not a substitute for pesticide labeling. Always read and understand the product label before using any pesticide.

2025 Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production

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Abbreviations and Symbols Used in This Publication

A	acre	F	flowable	S	soluble
AI	active ingredient	G	granular	SP	soluble powder
D	dust	L	liquid	ULV	ultra-low volume
DF	dry flowable	LFR	liquid fertilizer ready	W	wettable
DG	dispersible granule	MOA	mode of action	WDG	water-dispersible granules
DTH	days to harvest	OLP	other labeled product	WP	wettable powder
E	emulsion, emulsifiable	P	pellets	WSP	water soluble packet
EC	emulsifiable concentrate	PHI	pre-harvest interval		
EIQ	environmental impact quotient	REI	restricted-entry interval		

* ....Restricted-use pesticide; may be purchased and used only by certified applicators

† ....Not for use in Nassau and Suffolk Counties

Every effort has been made to provide correct, complete, and up-to-date pest management information for New York State at the time this publication was released for printing (January 2025). Changes in pesticide registrations, regulations, and guidelines occurring after publication are available in county Cornell Cooperative Extension offices or from the NYSIPM Program Pesticide Safety Education (psep.cce.cornell.edu).

Trade names used herein are for convenience only. No endorsement of products in intended, nor is criticism of unnamed products implied.

These guidelines are not a substitute for pesticide labeling. Always read the product label before applying any pesticide.

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

Cover photo: Leafy greens in Long Island, Suffolk County, NY. (*Photo by: Daniel W. Heck, School of Integrative Plant Science, Plant Pathology and Plant-Microbe Biology Section)*

Chapter 1 – Integrated Crop and Pest Management

1.1 Background

Cornell University and Cornell Cooperative Extension actively promote the use of Integrated Crop and Pest Management by New York farmers in order to address agricultural concerns. In many areas of New York State, there are horticultural, economic, social, and political pressures to reduce environmental impacts of and pesticide use in crop production. Public concerns with nutrient and sediment movement into ground and surface water and pressure against pesticide applications are growing. In other regions, agricultural producers are being asked to submit nutrient and soil management plans to address the offsite impacts of their practices. In addition, the development of pesticide resistance in key pests; registration of fewer and more expensive new chemicals for pest control; loss of existing products; and increased competition from other regions continue to push New York agriculture to look for nonchemical alternatives.

Integrated Crop and Pest Management requires a combination of long and short term production strategies to maximize net profit while minimizing risks of undesirable environmental impacts of practices. Some of these practices include site selection, crop specific production strategies, nutrient management, and cover cropping. IPM is a pest control strategy that promotes the use of a variety of tactics including pest resistant cultivars and biological, cultural, and physical controls. Pesticides are a control tactic employed in IPM, but they are only used when needed. Pesticide use is thus minimized without jeopardizing crop quality or yield. Applying multiple control tactics minimizes the chance that pests will adapt to any one tactic and allows farmers to choose the most environmentally sound, efficacious, and economically efficient pest management program for their situation.

This manual provides information and references which will allow New York vegetable growers to practice IPM for many of their crops. While information for the proper use of pesticides is included in the manual, a variety of other information is included that can help growers reduce reliance on pesticides and take advantage of alternatives to pesticides which may be less expensive, less environmentally harmful, and more acceptable to the non-farming community.

Visit the New York State Integrated Pest Management Program (https://cals.cornell.edu/new-york-state-integrated-pest-management) and Northeastern IPM Center (https://www.northeastipm.org) for more information.

1.2 Practicing IPM

In an IPM program, it is important to accurately identify the pests (vertebrates, diseases, insects, and weeds) and assess pest abundance. It is important to have knowledge of the biology and ecology of the pest(s) attacking the crop and the factors that can influence pest infestations. An understanding of the influence of factors such as weather and natural enemies on pest abundance will aid the choice of management tactics. IPM programs stress suppression of insect and disease populations to levels that do not cause economic damage, rather than total eradication of a pest. In the case of insect pests, it is important to have at least some pests present to ensure that natural enemies will remain in the crop to suppress subsequent infestations.

1.3 IPM Components

1.3.1 Monitoring (Scouting)

Scouting includes detecting, identifying, and determining the level of pest populations on a timely basis. Insect traps can often be used to detect pests and identify times when scouting should be intensified or control measures should be taken. Scientifically based, accurate, and efficient monitoring methods are available for many pests on vegetable crops in New York. Brief descriptions of the techniques are given in this manual.

1.3.2 Forecasting

Weather data and other information help predict when specific pests will most likely occur. Weather-based pest forecast models for diseases and insects of many crops have been developed in New York. This manual indicates which pests have such models available. Forecasts are available through the Network for Environment and Weather Applications (NEWA) on a daily basis.

Access to a computer network to obtain weather, regional insect, and disease forecasts, is useful but not essential. The Northeast Weather Association provides automated local weather information and the results of pest forecasts on a daily basis. Information on the potential for pest outbreaks can sometimes also be obtained from local Cooperative Extension programs, newsletters, and regional crop advisors.

1.3.3 Thresholds

Use thresholds to determine when pest populations have reached a level that could cause economic damage. Thresholds have been scientifically determined by Cornell researchers. Following the thresholds indicated in this manual has reduced pesticide use by ten to 50 percent, saving significant money for growers.

1.3.4 Management Tactics

Appropriate management tactics to control pests include cultural, biological, and physical controls, as well as some of the simple and relatively inexpensive pesticide alternatives offered in this manual can result in significant savings to growers both in terms of pesticide use and crop loss. Often a thoughtful preventive measure taken before the crop is planted can result in significant savings of crop-rescue treatment dollars later in the season.

1.3.5 Recordkeeping

Records kept from year to year on pest occurrence in fields can be valuable tools for avoiding pests in the future.

1.4 IPM Tactics

An important aim of an IPM strategy is to integrate the available pest management options. Some pests are endemic and usually require pesticide treatment, applied either at planting or during the season. However, the incidence of these pests and the need for pesticides can often be reduced through a combination of control tactics described below. A list of specific management options is included for each crop pest in later sections of this manual.

1.4.1 Pest Resistant Cultivars

If available, insect and disease resistant or tolerant cultivars can reduce losses to pests. Recommended pest resistant/tolerant cultivars and the pests they are tolerant or resistant to are listed for each crop. Using these cultivars can be one of the simplest methods of reducing costly management procedures and negative environmental impacts during the growing season.

1.4.2 Cultural and Physical Controls

Rotate crops to reduce the buildup of weeds, disease, and insect pests. Crop rotation is useful for those pests that do not move far from their overwintering sites.

Remove overwintering sites, such as cull piles, damaged and volunteer plants, and alternate hosts, to minimize damage by insects and diseases.

Use techniques that expose pests to natural enemies or environmental stress, or that make the crop less susceptible to insects or diseases.

Adjust planting times to avoid periods of peak pest abundance.

Plant disease-free seed and transplants.

Ensure vigorous crop growth through proper nutrition and weed removal to avoid stress that may predispose crops to attack by insects, diseases, or physiological disorders.

If irrigating, manage irrigation schedules to avoid long periods of high relative humidity which encourage disease pests to develop.

Avoid planting susceptible crops into areas of known, high pest pressure.

Orient fields to provide maximum air drainage and circulation.

Where cultivation or nitrogen side-dressing is routine, use cultivation for weed control in combination with banding of herbicides over the row. This technique can reduce herbicide costs by as much as 60 percent while achieving good weed control.

1.4.3 Biological Control

Conserve natural enemies of insect and mite pests by only using fungicides and insecticides when needed.

Provide refuges of flowering plants and shrubs to supply nectar, alternative hosts, and shelter for natural enemies. Make use of inundative releases of predators and parasites if available and effective.

See Biological Control: A Guide to Natural Enemies of North America (https://biocontrol.entomology.cornell.edu) for additional information.

1.4.4 Chemical Control

Only use pesticides if monitoring, economic thresholds, or disease forecasts indicate a need.

Choose pesticides according to efficacy, previous use patterns, the incidence of resistance, and the impact on the environment and natural enemies.

Ensure full and uniform spray coverage by using recommended spray rates and accurately calibrated equipment that targets key crop locations that need to be protected (i.e. the ears of sweet corn plants).

Do not apply pesticides when wind velocity is more than five miles per hour to avoid drift to non-target sites.

For more details about pesticide use, see Chapter 6.

Chapter 2 – Disease Management

2.1 General Principles

For a disease to develop in a vegetable crop, there are three critical factors that must occur together: a susceptible host plant, a virulent pathogenic organism, and environmental conditions favorable for the pathogen to survive, enter (infect) the plant, and thrive. This is referred to as the disease triangle. Additonal important factors are an effective method for distributing the pathogen and time for the disease to develop and become severe enough to impact yield. The choice of appropriate management practices for a particular disease must be based on accurate knowledge of the pathogen causing the disease; its life cycle; time of infection; the part of the plant involved; the method of pathogen distribution; past, present, and future environmental conditions; and certain economic considerations. Effective management practices include: resistant varieties; pathogen-free seed that was tested (certified) or grown in disease-free areas; treatment of seed with heat or chemicals; long rotations; sterilization of soil with steam or chemicals; control of insect vectors and weed hosts; and proper timing and application of organic and/or conventional fungicides and nematicides which entails weekly checking plants for disease symptoms and monitoring weather conditions.

Effective management of vegetable diseases starts with preventing disease onset when feasible. Next focus is on slowing development of diseases that occur. Procedures that can be done to prevent disease outbreaks or reduce the risk of early-season epidemics are: rotating where crops are grown, selecting resistant varieties, planting seed that has been tested and/or treated, controlling weeds, controlling insect vectors, minimizing leaf wetness periods (e.g. plant parallel to prevailing wind direction, use drip rather than overhead irrigation, trellise tomatoes), improving soil aeration and drainage, and practicing good sanitation (e.g. disinfecting greenhouse surfaces and tomato stakes after using). These are referred to as cultural practices. It is unlikely that all diseases of a particular crop can be controlled by just following these procedures. Often fungicides need to be applied as well. Nevertheless, the extent (incidence and severity) of disease, the number of fungicide applications, and the concomitant costs of achieving adequate control can be significantly reduced by following as many of these procedures as appropriate and feasible.

2.2 Diagnosis of Disease

The first step in disease management should be accurate diagnosis. It is important to differentiate between infectious diseases (which are those caused by fungi, bacteria, phytoplasma, viruses, viroids, and nematodes; all capable of multiplying and spreading from plant to plant) and noninfectious diseases or disorders (e.g., physiological disorders, air pollutants, nutrient imbalances, water imbalances, damage caused by mites and insects, and pesticide injury). Growers who have a reasonably good understanding of plant diseases, their symptoms, and the infectious and noninfectious disorders that can affect a particular crop, are more likely to make the correct disease control decisions. Numerous fact sheets and bulletins with full-color illustrations have been developed by Cornell faculty to assist growers in making accurate disease diagnoses. (See references in each disease section). In addition, samples can be sent to the Plant Disease Diagnostic Clinic in Ithaca (607-255-7850).

2.3 Disease Management Tactics

2.3.1 Crop Rotation and Tillage

Rotating, which is planting fields to different crops each year, cannot be overemphasized as one of the most important and easily implemented disease control strategies. This practice avoids buildup of plant pathogens that can survive in the soil. Not all pathogens are able to. Generally, the longer the rotation, the less likely that an early-season disease outbreak will occur. Knowledge about the target pathogen is important for achieving success with rotation, in particular how long the pathogen can survive in soil, what plants it can infect, and what are other potential sources of the pathogen.

Pathogens that can overwinter successfully only in association with plant debris and thus are unable to survive once the crop residue decomposes, are the main target for crop rotation. Fortunately there are many such pathogens. Hasten decomposition by chopping or mowing a crop as soon as possible after harvest followed by tillage. Small pieces of debris break down faster than larger pieces, and organisms that break down debris are in the soil. This will reduce the amount of inoculum that survives the winter.

To maximize success of rotation, avoid moving soil between fields on equipment and via runoff. It is best to rotate among separate fields. Do not rotate between adjacent blocks in a field.

Some soilborne diseases are not readily controlled by rotation. These include those caused by pathogens that can survive long-term in soil as ‘soil inhabitants’ (they cause root rots and include *Pythium* and *Phytophthora*), and those that produce structures that can withstand the effects of time and nonhost crops. Examples of these include clubroot of crucifers, Phytophthora blight and Fusarium wilt of several crops. Other pathogens have such a wide host range that they can survive indefinitely because so many crops and weed species serve as hosts. These pathogens include *Sclerotinia, Rhizoctonia, Verticillium* and root-knot nematodes.

Rotation will have limited impact on pathogens that produce spores capable of being dispersed long distance by wind. Some of the most important, downy and powdery

Soil preparation prior to fumigation. Soil should be plowed deeply (ten inches or more) in order to incorporate previous crop debris as thoroughly as possible and to prevent the turning up of nonfumigated soil during fitting in the spring. This should be followed by disking or any other means of fitting which will leave the soil in seedbed condition. Clods and poorly incorporated debris will provide “chimneys” through which fumigant can escape prematurely from the soil.

Soil moisture. The soil should be neither too wet nor too dry. A good rule of thumb is that moisture content is most favorable when soil will just “ball” in one’s hand when pressure is applied. If soil is excessively dry and irrigation is available, moisture supplementation before fumigation is recommended.

Soil temperature. The optimal temperature for most fumigants is 50° to 70°F. At warmer temperatures, fumigants dissipate thoroughly and rapidly, nematode larvae (which are easier to kill than eggs) have emerged, and all nematode stages can be more effectively controlled.

Crop debris. Undecomposed residues from previous crops prevent distribution of fumigant through the soil, irreversibly absorb fumigant, interfere with application equipment, prevent proper sealing of the soil surface, and protect nematodes and nematode eggs from fumigant action. Rake, burn, or deeply incorporate debris prior to fumigation.

Sealing of soil surface. It is essential that fumigated soil be thoroughly sealed as soon after application as possible. This can be achieved by means of equipment such as a cultipacker, chain harrow or float, or by means of spray irrigation or plastic sheets. A plastic film seal will increase the efficacy of fumigation.

Interval between fumigation and planting. Under average conditions, with a soil temperature of ± 50°F, a minimum of three weeks is regarded as necessary between fumigation and planting to prevent phytotoxicity. See fumigant labels for specific recommendations.

Table 2.3.1 Registered conventional fungicides by crop. See Table 4 in appendix for biopesticides which typically are labeled for all crops.

X = registered; Superscript numbers = preharvest interval (PHI) aka days to harvest. No number = 0 day PHI or intended for seed or soil use at planting. Note that harvest is not a permitted activity during the restricted-entry interval (REI) which is at least 12 hours for most fungicides. H = head lettuce, L = leafy lettuce.

	Crop																									
Fungicide (*active ingredient*)	FRAC Group	Asparagus	Bean, Dry	Bean, Snap	Beet	Broccoli	Brussels sprouts	Cabbage	Cabbage, Chinese	Carrot	Cauliflower	Cucumber	Eggplant	Lettuce and Endive	Melon	Onion, Dry bulb	Onion, GB	Peas	Pepper	Potato	Pumpkin, W. Squash	Spinach	Summer Squash	Sweet Corn	Tomato	Watermelon
Actigard (*acibenzolar-S-methyl*)	P 01					X^{7}	X^{7}	X^{7}	X^{7}		X^{7}	X		H^{7} L^{7}	X	X^{7}			Chili 14		X	X^{7}	X		X^{14}	X
Agri-mycin 17 (*streptomycin*)	**25**																		X	X					X	
Aliette WDG (*fosetyl-Al)*	P 07					X^{3}	X^{3}	X^{3}	X^{3}		X^{3}	$X^{0.5}$		X^{3}	$X^{0.5}$	X^{3}					$X^{0.5}$	X^{3}	$X^{0.5}$		X^{14}	$X^{0.5}$
*†Aproach (*picoxystrobin*)	**11**		X^{14}																							
Apron XL (*mefenoxam*), seed	**4**		X		X													X						X		
Aprovia Top (*difenoconazole + benzovindiflupyr*)	**3 + 7**		X^{14}	X^{14}								X	X		X	X^{7}	X^{7}	X^{14}	X		X		X		X	X
Blocker 4F (*PCNB*), application method varies	14					X	X	X	X		X									X						
Bravo, Echo, OLP *(chlorothalonil)*	M05	X^{190}	X^{14}	X^{7}		X^{7}	X^{7}	X^{7}	X^{7}	X	X^{7}	X			X	X^{7}	X^{14}			X^{7}	X		X	$X^{g,14}$	X	X
Cabrio EG (*pyraclostrobin*)	**11**				X	X	X	X	X	X	X	X	X	X	X	X^{7}	X^{7}		X		X	X	X		X	X
†Cannonball WG (*fludioxonil*)	**12**		X^{7}	X^{7}										X		X^{7}	X^{7}									

Chapter 3 – Insect Management

3.1 General Principles

The goal is to avoid or reduce insect pest populations to levels that do not cause economic loss. Management of insect pests should ideally include a variety of tactics that are integrated to reduce pest infestations and damage to acceptable levels and minimize the chance that pests will adapt to any one management tactic. In many cases, certain insect pest infestations never exceed economically damaging levels and do not require control. The most common management tactics used against insect pests include pest resistant or tolerant varieties, and cultural, physical, mechanical, biological, and chemical controls.

Integrated pest management requires an understanding of the pest's biology and ecology, the crop production system and the agroecosystem. For example, temperature is the primary factor determining the rate at which insects develop; higher temperatures increase the rate of development. Therefore, temperature can be important when determining the frequency of insecticide applications. Degree-day models for some insect pests are available on the Network for Environment and Weather Applications web site (newa.cornell.edu) and can aid in determining how fast insects are developing and the timing of applications. In addition to temperature, other factors influence the pest populations such as rainfall, host quality, host availability and the ability of the pest to disperse long distances.

Knowledge of when pests typically infest a crop and the crop stage that is most vulnerable to yield loss when damaged by the pest will impact the management options used. For example, if the pest attacks the seedling stage of the crop every year, a preventative tactic might be selected (e.g., resistant cultivar, insecticide at planting). If the pest only occasionally attacks the crop, a decision to control the pest should be made only when infestations are likely to reach an economically damaging level (see more below).

Understanding the population dynamics of insect pests in the agroecosystem can inform decisions about how best to manage the pest in the vegetable crop. For example, a pest may initially infest a crop (e.g., alfalfa or wheat) or non-crop (e.g., weeds) that do not require control, thereby allowing subsequent generations to build that may disperse into and damage a nearby vegetable crop.

Action Thresholds and Sampling. The decision to use an insecticide, or similar tactic, against an insect infestation requires an understanding of the level of damage or insect infestation a crop can tolerate without an unacceptable economic loss. The level of infestation or damage at which some action must be taken to prevent economic loss is referred to as the "action threshold." Action thresholds are available for many vegetable crops and should serve as a guide for making control decisions. Thresholds should be adjusted based on market value, environmental conditions, variety, etc. To estimate the severity of pest infestations, the crop must be sampled. Sampling may involve examining plants and recording the number of pests or the amount of damage observed, or traps may be used to capture the pest species to estimate pest activity and possibly abundance. Sampling is conducted at regular intervals throughout the season or during critical stages of crop growth.

3.2 Management Options

3.2.1 Pest-Resistant Crops

An important management option for the control of insect pests is the use of crop varieties that are resistant or tolerant. A resistant variety may be less preferred by the insect pest, adversely affect its development and survival, or the plant may tolerate the damage without an economic loss in yield or quality. For example, vine crops (squash, cucumbers, melons) that have lower concentrations of feeding stimulants (cucurbitacins) are less preferred by cucumber beetles. Sweet corn varieties with tight husks are less likely to be infested by corn earworm, and some varieties are resistant to the bacteria transmitted by corn flea beetle that causes Stewart's wilt. *Bacillus thuringiensis* (Bt) sweet corn varieties have been genetically engineered to resist European corn borer, corn earworm, fall armyworm and western bean cutworm. Some cabbage varieties have been classically bred to tolerate onion thrips damage. Advantages of pest-resistant or tolerant crop varieties include ease of use; compatibility with other integrated pest management tactics; low cost; cumulative impact on the pest (each subsequent generation of the pest is further reduced); and reduced negative impact on the environment.

3.2.2 Cultural Control

There are many agricultural practices that make the environment less favorable for insect pests. Crop rotation, for example, is recommended for management of Colorado potato beetle. Beetles overwinter in or near potato fields and they require potato or related plants for food when they emerge in the spring. Planting potatoes far away from the previous year's crop prevents access to needed food, and the relatively immobile beetles will starve. Selection of the planting site may also affect the severity of insect infestations. Cabbage planted near small grains is more likely to be infested by onion thrips that disperse from the maturing grain crops.

Trap crops are planted to attract and hold insect pests where they can be managed more efficiently and prevent or reduce their movement onto cash crops. Early-planted potatoes can act as a trap crop for Colorado potato beetles emerging in the spring. Because the early potatoes are the only food source available, the beetles will congregate on these plants where they can be more easily controlled. Adjusting the timing of planting or harvesting is another cultural control technique. Earlier planted sweet corn is less likely to be

Table 3.2.1 Some commonly used insecticides on vegetables.
Not all registered products are listed in this table or in crop sections.

		Crop																					
Insecticide ***(Active Ingredient)***	*Mode of Action*[1]	Asparagus	Bean, Dry	Bean, Snap	Beet	Broccoli	Brussels sprouts	Cabbage	Cabbage, Chinese	Carrot	Cauliflower	Cucumber, Melon, and Watermelon	Eggplant	Lettuce and Endive	Onion, dry bulb	Onion, green bunching	Peas	Pepper	Potato	Pumpkin and S/W Squash	Spinach	Sweet Corn	Tomato, field
*Provado (*imidacloprid*)	*4*			X		X	X	X	X		X		X					X	X				X
Radiant SC (*spinetoram*)	*5*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sevin XLR (*carbaryl*)	*1A*	X	X	X		X	X	X	X	X	X	X	X						X	X		X	X
*Vendex 50W (*fenbutin-oxide*)	*12*												X										
*†Voliam Xpress (*chlorantraniliprole + lambda-cyhalothrin*)	*3, 28*		X	X		X	X	X	X		X	X		X				X	X	X		X	X
*Warrior II with Zeon Technology (*lambda-cyhalothrin*)	*3*		X	X		X	X	X	X		X	X			X			X	X	X		X	X
Xentari (*Bt var. aizawai*)	*11*					X	X	X	X		X												

* Restricted-use pesticide † = Not for use in Nassau/Suffolk Counties
[1]Modes of Action
[2]Except cucumber
[3] Head lettuce only.

Insecticides with different numbers mean that they have different sites of action and are not likely to be cross resistant. In some cases the number may be followed by different letters, meaning that they have the same target site but may not have developed significant cross resistance. When only insecticides from the same numbered group are available, alternation of compounds from subgroup A and subgroup B is recommended.

Where insecticide resistance is an issue, switch modes of action throughout the season.

Chapter 4 – Weed Management

4.1 General Principles

Weeds reduce yield and quality of vegetables by competing directly for light, nutrients, and water. Weeds can also serve as alternate hosts for insects and pathogens and uncontrolled vegetation can reduce air circulation around plants, creating more favorable conditions for plant disease development. Weeds with thorns or spines or that produce dermatitis inducing substances can be direct hazards to workers. While a comprehensive weed control system integrates tools and practices throughout all phases of production, early-season competition can significantly impact future yield potential and control should be emphasized during this period. However, weeds that remain in-crop at the end of the season can significantly impede harvest operations; additionally, seeds, stems, and other plant parts can result in contamination that reduces yield quality. Weed species vary, considerably, with respect to their emergence patterns, life history traits, size and competitive ability, among other attributes, and cannot be controlled using a single method. Consequently, the first step in developing an effective management strategy is proper identification. Recommended guides for weed identification (ID) include the second edition of "Weeds of the Northeast" by J.C. Neal, R. H. Uva, J. M. DiTomaso, and A, DiTommaso (ISBN 978-1-5017-5572-9). Phone applications ("apps") that can be used to identify plant species from photos, such as Seek by iNaturalist, PlantSnap, Pl@ntNet, and Google Lens, among many others. Be sure to double check results with other sources like the aforementioned guide. The Virginia Tech weed identification website is also a recommended tool (https://weedid.cals.vt.edu/).

4.1.1 Problem Weeds in Vegetable Production

Galinsoga. Galinsoga is an upright summer annual with opposite, egg- to triangular-shaped leaves with toothed margins. Because of its biology and its tolerance to vegetable herbicides, galinsoga may quickly become a major weed once it is introduced into a vegetable field. The species is not sensitive to day length and, as a consequence, begins to flower and produce seed when it has about five or six pairs of leaves and continuing until the plants are killed by frost. Fresh seed that drops onto the soil surface can germinate almost immediately because there little or no dormancy. Three to five generations per season have been observed in Ithaca, New York. Cultivation is only partially helpful because Galinsoga can re-root, easily, and re-establish itself from cut stems unless conditions are very dry for several days following soil disturbance.

Velvetleaf. This erect, robust, summer annual weed is increasing rapidly in upstate New York areas. The species comes by its name, honestly, because its stems and heart-shaped leaves are hairy and soft to the touch. It often escapes in fields where preemergence herbicides are used without mechanical cultivation. It has fairly large seeds that last many years in the soil and are not destroyed when fed to cattle. Because of their size, seeds can germinate anywhere in the top several inches of soil. Subsequently, seedlings can emerge from a range of depths, appearing over a period of many weeks, and most surface-applied herbicides used at planting are relatively ineffective on late-emerging plants. Unfortunately, even late seedlings can reach reproductive maturity and produce mature seeds before frost.

Nightshades. Nightshades are warm-season, annual weeds. Eastern black nightshade (*Solanum ptycanthum*) is the most common and widespread species in New York, although hairy nightshade (*Solanum sarracoides*) is predominant in some areas. It can be difficult to distinguish among the *Solanum* species, especially at the seedling stage. Eastern black nightshade is characterized by smooth egg- to triangular-shaped leaves and glossy, purple to black berries; hairy nightshade has hairy leaves and stems and green to yellow berries. These weeds are particularly problematic in tomato, potato, snap bean, and dry bean fields. Relatively few herbicides currently registered for use in vegetable crops are effective for controlling nightshades. Therefore, to stop an infestation, it is important to correctly identify the weed and eradicate it before the plants produce seeds.

Pigweeds. Pigweeds (*Amaranthus* species) are a group of highly aggressive, fast-growing annual weeds commonly found in agricultural fields. They can be identified by their broad, egg-shaped to lanceolate leaves that are often smooth or slightly hairy, with stems that are reddish or green and can grow several feet tall. Pigweeds produce small, inconspicuous flowers that form dense clusters at the top of the plant. Their extended emergence window, rapid growth, prolific seed production (thousands to hundreds of thousands per plant), and adaptability to a wide range of environments make them difficult to control. Differences in leaf, stem, and inflorescence morphology can make it difficult to distinguish individual species from each other. See the Cornell pigweed ID website for more information (https://cals.cornell.edu/weed-science/weed-identification/pigweed-identification). Accurate ID can be difficult but critical as new pigweed species with known herbicide resistance traits have started to invade New York, including Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*).

Common lambsquarters. Common lambsquarters can be identified by its upright growth habit and diamond-shaped leaves with toothed edges. The leaves are often grayish-green, particularly the new growth, which may have a whitish, mealy appearance. Lambsquarters can grow >5 feet tall and produce small, inconspicuous green flowers in dense clusters at the tips of its branches which can result in significant seed production. Like common ragweed, lambsquarters first emerges in the early spring although

Table 4.2.1 Commonly used herbicides on vegetables in New York.
Not all registered products are listed in this table or in crop sections.

Herbicide (*Active Ingredient*)	*Mode of Action*[1]	Asparagus	Bean, Dry	Bean, Snap	Beans, Lima	Beet	Broccoli	Brussels sprouts	Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Lettuce and Endive	Melon	Onion	Peas	Pepper	Potato	Pumpkin	Spinach	Squash	Sweet Corn	Tomato, field	Watermelon
		Crop																							
Prefar 4E (*bensulide*)	*8*						X	X	X		X	X	X	X	X	X		X				X			X
Prowl H_2O (*pendimethalin*)	*3*	X	X	X	X		X	X	X	X	X				X	X	X	X	X				X	X	X
Raptor (*imazamox*)	*2*		X	X	X												X								
*Reflex (*fomesafen*)	*14*		X	X	X												X[2]			X[2]		X[2]			
Roundup WeatherMax (*glyphosate*)	*9*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sandea (*halosulfuron*)	*2*	X	X	X	X							X	X		X			X		X		X		X	X
*Select Max (*clethodim*)	*1*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
*†Sharpen (*saflufenacil*)	*14*			X													X						X		
Sonolan HFP (*ethalfluralin*)	*3*		X																						
*Spin-Aid (*phenmedipham*)	*5*					X															X				
*†Stinger (*clopyralid*)	*4*					X	X	X	X		X					X[2]					X		X		
Strategy (*ethalfluralin + clomazone*)	*3/13*											X			X					X		X			X
Treflan HFP (*trifluralin*)	*3*	X	X	X	X		X	X	X	X	X						X	X	X					X	

[1]Modes of action:
1= Inhibitors of acetyl CoA carboxylase (ACC) (graminicides)
2=Inhibitors of acetolactate synthase (ALS/AHAS) (sulfonyl ureas)
3=Inhibitors of microtubule assembly (dinitroanilines)
4=Synthetic auxins (growth regulators) (e.g. 2,4-D)
5=Inhibitors of photosystem II Site A (triazines)
6=Inhibitors of photosystem II Site B (bentazon, bromoxynil)
7=Inhibitors of photosystem II Site A-II (ureas)
8=Inhibitors of lipid synthesis (thiocarbamates)
9=Inhibition of EPSP synthase (glyphosate)
13=Inhibition of DOXP synthase (clomazone)
14=Inhibitors of Protox (diphenyl ethers)
15=Inhibition of long chain fatty acids (chloroacetamides)
19=Inhibitors of indolacetic acid (IAA) (phthalamates napthalam)
22=Inhibition of photosystem I (paraquat)
27=Inhibition of hydroxyphenyl-pyruvate-dioxygenase (HPPD) (triketones, pyrazolones)

[2] Under Special Local Needs registration.
* Restricted-use pesticide † Not for use in Nassau and Suffolk Counties

Table 4.2.2 Relative effectiveness of herbicides for vegetables.[1]

	Broadleaf annuals[2]									Annual Grasses				Perennials	
	CL	**CP**	**CR**	**P**	**S**	**GA**	**M**	**N**	**V**	**B**	**C**	**FP**	**FS**	**Q**	**YN**
Preemergence Surface-applied Herbicides															
*†AAtrex 4L	E[3]	E	E	E	E	E	E	G	F	G	F	P	G	G	F
Callisto	E	-	F-G	E	E	E	-	E	G-E	P	F	P	P	P	P
Chateau EZ	E	E	P	E	P	G	G	E	P	P	P	P	P	P	P
Curbit EC	F	-	P	G	P	P	P	P	P	E	E	G	E	P	P
*†Dual Magnum	P	F	P	F	F	E	P	G	P	E	E	E	E	P	G
GoalTender	G	G	F	E	G	F	F	G	P	P	P	P	P	P	P

Chapter 5 – Wildlife Damage Management

5.1 Deer

5.1.1 Nonchemical Alternatives

A vegetable grower can use a variety of nonchemical alternatives to reduce deer damage to crops. These techniques fall into three primary categories: exclusion, population reductions, and habitat modification. Fencing is the most common exclusion technique used to prevent deer damage. Woven-wire designs are the most effective physical barrier, with high-tensile, woven-wire fencing providing the ultimate in protection and durability. Deer can be successfully eliminated from large areas with an eight to ten foot high woven-wire fence. The advantages of this design are its effectiveness and low maintenance requirements after construction. Disadvantages include the high initial cost and the difficulty in repairing damaged sections.

A variety of multi-strand, high-tensile, vertical, or sloped electric fence designs may effectively exclude wildlife. Electric high-tensile fences can be complete physical barriers, or more often, act as psychological deterrents. Deer can be excluded from crops with a five to six foot electric fence, even though they can easily jump over fences of this height. The most frequent reasons why electric fences fail to prevent deer damage include: the selection of an unsuitable fence design, the failure to install fencing according to specifications, and inadequate maintenance. High-tensile electric fences are more easily repaired than conventional fences, and may cost half as much as eight to ten foot woven-wire designs. Disadvantages include the need for frequent monitoring and vegetation control to maintain shocking power. Single-strand electric fences, combined with cloth strips treated with deer repellents or aluminum foil tabs coated with peanut butter to act as an attractant, and attached at three to four foot intervals along the fence, have successfully reduced summer deer damage to vegetables. High-visibility, electric polytape fences on fiberglass stakes provide another low-cost, portable design that can effectively reduce deer damage to vegetable crops.

Posting of private lands reduces the opportunity for sportsmen to harvest antlerless deer. Deer populations are regulated through the removal of breeding-age does. Growers who experience recurring deer damage should invite hunters to their property and mandate that they fill an antlerless tag (if available) before harvesting a buck. Reducing deer numbers on a unit-wide basis may lower crop losses. Deer depredation permits issued on a farm-by-farm basis have not controlled crop losses in other states.

Deer problems are most severe in fields near escape or resting cover. Mowing or removing brush in fields adjacent to crops may make the sites less attractive for deer and other problem wildlife. Some growers have experimented with lure crops to draw deer away from important harvestable fields, however, these efforts have had mixed success.

5.1.2 Repellents

Repellents may be cost-effective for controlling wildlife damage when light to moderate damage is evident, small acreage is damaged, and only a few applications will be needed for adequate control. If these three conditions are not satisfied, it is best to look at the cost-benefit ratios of alternative control measures.

With the use of repellents, some damage must be tolerated, even if browsing pressure is low. None of the existing repellents provide reliable protection when deer densities are high. Repellents should be applied before damage is likely to occur, when precipitation is not expected for 24 hours, and temperatures will remain between 40° to 80°F for that period. Hand-spray applications may be cost effective on small acreages, while machine sprays will reduce costs for larger areas. If the materials are compatible, spray costs may be reduced by adding repellents to pesticide sprays. If browsing pressure is severe, a long-term damage management program should be implemented. Such a program should include potential habitat modifications, reductions in animal numbers, and an evaluation of fencing alternatives.

5.2 Woodchucks

Woodchucks are game animals in New York and can be hunted throughout the year without limit. A hunting license is required to harvest woodchucks. Woodchucks causing damage can be destroyed without a license under New York Conservation Law. Consult your regional Department of Environmental Conservation (DEC) office if you have questions about a specific situation.

Growers have usually relied on lethal controls to reduce woodchuck damage. Spring is the best time to use lethal controls, because adults are active and young animals may remain within their burrow at this time. In addition, burrows are more evident before annual vegetation conceals their entrances, and other wildlife are less likely to use burrows as shelter at this time.

Shooting or trapping methods can be used to remove problem woodchucks from fields containing edible crops. It may be illegal or unsafe to shoot woodchucks under some circumstances. Woodchucks can be captured using #2 leg-hold traps, #160 or #220 body grips, or live traps baited with apples and set near burrow entrances. Traps should be checked at least twice daily. Only live traps should be used where pets or livestock might be inadvertently captured.

Lethal controls have been reported to have limited success in controlling woodchuck populations. Twenty-eight

Chapter 6 – Pesticide Information and Use

6.1 Pesticide Classification and Certification

Pesticides can be classified as general-use or restricted-use. **General-use pesticides** may be purchased and used by anyone. **Restricted-use pesticides** can only be purchased and used by a certified applicator or used by someone under a certified applicator's supervision. In some cases, the pesticide label may limit use of a restricted-use pesticide to only a certified applicator.

Private applicators use or supervise the use of pesticides to produce agricultural commodities or forest crops on land owned or rented by the private applicator or their employer. If a private applicator wants to use or supervise the use of restricted-use pesticides, they need to be a **certified private applicator**. Certified private applicators are also allowed to purchase restricted-use pesticides. Certification is not needed if a private applicator uses general-use pesticides.

In New York State, a **certified commercial applicator**, **certified commercial technician**, or **commercial apprentice** working under the supervision of a certified commercial applicator is allowed to apply any type of pesticide on property that is not a private application (described above) or is a residential application. (A residential application is the use of general-use pesticides on property owned or rented by the applicator, excluding establishments selling or processing food and residential structures other than where the applicator lives.) Certified commercial applicators are allowed to purchase restricted-use pesticides.

Information on pesticide certification and classification is available from your Cornell Cooperative Extension office (cce.cornell.edu/localoffices), regional NYSDEC pesticide specialist (dec.ny.gov/about/contact-us/statewide-office-information), the Pesticide Applicator Training Manuals (www.cornellstore.com/books/cornell-cooperative-ext-pmep-manuals), or the Cornell Pesticide Safety Education Program (psep.cce.cornell.edu).

6.2 Use Pesticides Properly

Using pesticides requires the user to protect their health, the health of others, and the environment. Keep in mind "pesticide use" is more than just the application. It includes mixing, loading, transporting, storing, or handling pesticides after the manufacturer's seal is broken; cleaning pesticide application equipment; and preparing a container for disposal. These activities require thoughtful planning and preparation. They also require you to comply with state and federal laws and regulations intended to protect human health and the environment from the adverse effects pesticides may cause.

6.2.1 Plan Ahead

Many safety precautions should be taken *before* you begin using pesticides. Most pesticide accidents can be prevented with informed and careful practices. **Always read the label on the pesticide container before using the pesticide.** Make sure you understand and can follow all label directions and precautions. Be prepared to handle an emergency exposure or spill. Know the first aid procedures for the pesticides you use.

6.2.2 Move Pesticides Safely

Transporting pesticides carelessly can result in broken containers, spills, and contamination of people and the environment. Accidents can occur even when transporting pesticides a short distance. You are responsible for a pesticide accident so take every effort to transport pesticides safely. Be prepared for an emergency.

6.2.3 Personal Protective Equipment and Engineering Controls

Personal protective equipment (PPE) needs depend on the pesticide being handled. **Required PPE are listed on pesticide labels.** Any required PPE is based on the pesticide's toxicity, route(s) of exposure, and formulation. Label-listed PPE are the minimum that must be worn when using a pesticide. You can always use more than what's listed!

The type of PPE used depends on the type and duration of the activity, where pesticides are being used, and the user's exposure. For example, mixing/loading procedures often require more PPE than when applying a pesticide. Studies show you are at a greater risk of accidental poisoning when handling pesticide concentrates. Pouring pesticide concentrates is the most hazardous activity.

Engineering controls are devices that help reduce a pesticide user's exposure. An example is a closed transfer system that reduces the exposure risk when dispensing pesticide concentrates. Consult the product label for more information on using engineering controls in place of PPE.

6.2.4 Avoid Drift, Runoff, and Spills

Pesticides that move out of the target area can injure people, damage non-target areas, and harm the environment. Choose weather conditions, pesticides, application equipment, pressure, droplet size, formulations, and adjuvants to minimize drift and runoff potential. Product labels may have specific application and/or equipment requirements to reduce issues with drift and runoff.

6.13.4 Travel Speed Calibration

Travel speed is a critical factor in maintaining accurate application rates and will influence spray deposition depending on location within the canopy. The slower a sprayer travels, the greater the uniformity in spray deposition. Although there is inconsistency in research results that try to determine the effect of travel speed on average spray deposition, all studies to date have been in agreement that the higher the travel speed, the greater the variability in spray deposit. Variation in spray deposit is an important factor where uniformity of spray coverage throughout the canopy is required. Conclusions from research were drawn using travel speeds of 1-4 mph.

- Factors that will affect travel speed include:Weight of sprayer to be pulled.
- Slope of terrain.
- Ground conditions traveled over (wheel slippage).

The best way to measure travel speed is to pull a sprayer with the tank half filled with water on the same type of terrain that the sprayer will be operated on.

Set up test course at least 100 feet long, measure the course with a tape measure. Do not pace the distance. The longer the course, the smaller the margin of error. Run the course in both directions.

Use an accurate stop watch to check the time required to travel the course in each direction. Average the two runs and use the following formula to calculate the speed in MPH.

Formula: $\text{MPH} = \dfrac{\text{ft. traveled}}{\text{sec. traveled}} \times \dfrac{60}{88}$

Your figures:

Tractor gear ___________ Engine revs.___________

$\text{MPH} = \dfrac{\text{ft. traveled}}{} \times \dfrac{60}{88} = \quad$ sec. traveled

6.13.5 Boom Sprayer Calibration

Step 1. Record your tractor sprayer speed from above

MPH = _______________

Step 2. Record the inputs

	Your Figures	Example
Nozzle type on your sprayer (all nozzles must be identical)	____________	11004 flat fan
Recommended application volume GPA(from manufacturer's label)	____________	20
Measured sprayer speed	____________	4 MPH
Nozzle spacing	____________	20 inches

Step 3. Calculate the required nozzle output

Formula: $\text{GPM} = \dfrac{\text{GPA x mph x nozzle spacing}}{\text{5940 (constant)}}$

Example: $\text{GPM} = \dfrac{20 \times 4 \times 20}{5940} = \dfrac{1600}{5940} = 0.27$ GPM

Your figures: $\text{GPM} = \dfrac{\_\_\ \text{x}\ \_\_\ \text{x}\ \_\_}{5940} = \dfrac{\_\_\_\_}{5940} =$ GPM

Step 4. Operate the sprayer

- Set the correct pressure at the gauge using the pressure regulating valve.
- Collect and measure the output of each nozzle for one minute.
- The output of each nozzle should be approximately the same as calculated in Step 3 above.
- Replace all nozzle tips more than 10% inaccurate

6.13.6 Banded Boom Sprayer Calibration

The only difference between the boom sprayer calibration mentioned above and calibrating for a banded sprayer is the input value used in the formula in Step 3.

For a single nozzle banding applications:

Nozzle spacing = sprayed band width or swath width (in inches)

For multiple nozzle directed applications:

Nozzle spacing = row spacing (in inches) divided by the number of nozzles per row.

Minimally, vegetable sprayers should be calibrated at the beginning of the spraying season. Accuracy is important to any calibration technique. The more accurate the measurements, the more accurate and reliable the calibration calculations. If nozzle output (gpm) at the desired operating pressure varies more than 10% from the manufacturer's specification, the nozzle should be replaced. Volume measurements should be made to the nearest 1/2 ounce when collecting small volumes of water. Time should be measured to the nearest 1/10 second. Nozzle performance should be checked frequently because nozzles may wear, especially when operated at high pressures or if used to apply abrasive materials. Local Cooperative Extension offices can supply additional information about the details of sprayer calibration.

6.13.7 Minimizing Pesticide Drift

Spray drift of pesticides is an important and costly problem facing pesticide applicators. Drift results in damage to susceptible off target crops, environmental contamination to watercourses and a lower than intended rate to the target crop, thus reducing the effectiveness of the pesticide. Pesticide drift also affects neighboring properties, often leading to concern and legal action.

Chapter 7 – General Culture

7.1 Mulches

7.1.1 Types

Use of plastic mulch is common throughout New York, particularly for vine crops, peppers, and tomatoes. Several types of plastic mulches are available. All protect ground-level fruit from soil pathogens, conserve soil moisture, reduce leaching of mobile nutrients such as nitrogen, and warm the soil. The disadvantages of mulches include the environmental cost to produce and dispose of the plastic and the cost of materials and labor for application and removal. In addition, although they conserve soil moisture, rain and irrigation water may never reach the roots if the soil is dry when mulches are applied.

Black plastic is probably the best weed control measure available and a good alternative to herbicides. Two main disadvantages of using black compared to clear plastic are that (1) soil temperatures are cooler under black plastic than under clear, so black plastic is less effective at stimulating early crop growth and yield; and (2) if black plastic is used with a row cover, air temperatures can become excessive on warm days and damage the crop.

Clear plastic causes warmer soil temperatures than black plastic, resulting in earlier harvest. Some growers also claim that clear plastic leads to larger fruit size and better quality. The main disadvantage of clear plastic is weed control. Clear plastic creates an ideal situation for weeds, and herbicides must be used to prevent harm to the crop.

Infrared-transmitting (IRT) plastic is relatively new and more expensive than conventional plastics, but it may be worth trying because of its special properties. Basically, IRT plastic is a hybrid between clear and black plastic in that it prevents weed growth (as does black plastic) by screening out light energy the weed seedlings need to grow but allows infrared light to pass through, thereby warming the soil more effectively than black plastic. In trials at Cornell University, soil temperatures under IRT mulches have been halfway between clear and black plastic; IRT usually results in greater early yields than black plastic but lower yields than with clear plastic.

Reflective, aluminum-faced, plastic mulch interferes with the movement of aphids, which are insect vectors of diseases such as cucumber mosaic virus. Use of reflective mulches in regions with significant insect pressure reduces the spread of these diseases.

Red, white, and yellow plastic mulches have been tested for their effect on early yield of some crops. Although results have been inconclusive, the theory behind the use of colored mulches is sound. Plant development (e.g., stem elongation and flowering) is sensitive to the ratio of far-red to red wavelengths that strike the leaves and shoots. Different mulch colors affect this ratio and therefore can potentially affect plant development and possibly increase early yield. Initial studies conducted by the USDA and other researchers suggest that certain crops had higher yields with specific colors of mulch, independent of the effect on soil temperature. Research with tomatoes at Cornell showed no significant yield advantage using colored mulches. More conclusive information and guidance for growers may be available at a later date.

Use of photodegradable plastics has increased because of environmental concerns and regulations regarding the disposal of nondegradable types. The products now on the market usually degrade thoroughly once the process begins, but inaccuracy in timing of breakdown has discouraged some growers. It is usually necessary to experiment with a few different formulations to find what will work best for a particular farm management system. Buried edges must be brought to the surface at the end of the season and exposed to light before they will degrade, but these remnants have not been a major problem for most growers. The primary byproducts of degradation are small amounts of carbon dioxide and water, which are relatively harmless. Trace amounts of nickel or other elements (depending on type) may also be left behind. Biodegradable plastics exist, but none are currently being used on a large scale for mulch film in the United States. Another option, recycling of agricultural plastics, requires a considerable infrastructure for collecting, cleaning, and reusing the plastic that does not yet exist in the United States.

7.1.2 Application and Disposal

Before laying plastic mulch, the soil should be prepared using special precautions. Good soil moisture is essential at the outset because supplemental water applied later through the holes where the transplants are placed usually will not be adequate for maximum growth. Many growers use drip irrigation under the plastic, which is an excellent, although costly, technique for ensuring optimal soil moisture and best response to the mulch.

A tight fitting mulch, which requires a flat soil surface, will help control weeds by burning seedlings as they touch the plastic. It also prevents a whipping action that can damage transplants on windy days.

Initial fertilizer and herbicide applications must also precede laying of plastic. Late-season supplemental fertilizer applications at the outer edge of plastic can be effective when plants are large enough to have roots in this region. "Fertigation," feeding liquid fertilizer through a drip irrigation system, is another option. See Section 8.7.6 in the Soil Management chapter.

Most growers use a commercially-available plastic layer for installation. Disks are used to open small trenches on each side of the plant row, and then the edges of the plastic are

Table 7.5.1. Approximate rooting depth of various vegetable crops when grown in deep, well drained soils.

Very shallow	Shallow	Intermediate	Deep
(Down to 1 1/2')	*(Down to 2')*	*(Down to 4')*	*(Down to 6')*
Celery	Broccoli	Bean, snap	Asparagus
Lettuce	Cabbage	Beet	Bean, lima
Onion	Cauliflower	Carrot	Parsnip
Radish	Cucumber	Eggplant	Pumpkin
	Muskmelon	Pea	Winter squash
	Pepper, transplanted	Pepper, seeded	Tomato, seeded
	Potato	Rutabaga	Watermelon
	Spinach	Summer squash	
	Tomato, transplanted		

7.6 Food Safety

Attention to the microbial food safety of vegetable crops that are eaten raw is important to both produce growers and consumers. Microbial food safety risks can be found on every farm and can be managed as long as growers are aware of the risks. Microbial pathogens can contaminate vegetables during all phases of production, harvesting, and packing. Wild and domesticated animals, manure, irrigation water, inadequate worker hygiene, unclean picking containers, unsanitized postharvest water, and unclean packaging materials are all potential vectors of microbiological pathogens. Growers should assess their microbial risks and implement practices to reduce risks. There are many resources available to help including those at the National Good Agricultural Practices Program or the Produce Safety Alliance. Growers should also be aware they may be subject to the Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR) if they grow, harvest, pack or hold vegetables in an unprocessed state and exceed specified gross income levels. Regardless if vegetable growers are legally subject to the FSMA PSR, all vegetable growers should be using food safety practices to reduce microbial risks on their farms to ensure the health and well-being of their customers, to maintain market access, and to protect the economic viability of their farms.

Chapter 8 – Soil Management

8.1 Soils and Fertility

Fertility management is part of overall soil management involving proper tillage practices, crop rotation, cover crops, water management (irrigation and drainage), liming, weed management, and produce safety considerations. Although it is important in obtaining maximum economic yields, fertilization alone will not overcome shortcomings in the other areas mentioned above. Such problems should be corrected first so as to benefit fully from organic and inorganic fertilizer supplements and to sustain high yields and quality over the long term. Information on Soil Testing, Soil pH and Fertilizers is below in sections 8.8, 8.9 and 8.10.

8.2 Field and Soil Evaluation

Plan ahead when selecting new lands or fields. Soils for growing vegetables should be well drained, fairly deep, reasonably level, properly limed, and in good tilth (have good structure). Medium-textured soils (sandy to silty loams with good organic-matter content) are generally most satisfactory; well-drained, sandy soils with a slight to moderate southern slope are most favorable for early plantings and certain warm-season vegetables. For a summary of soil types and soil management groups in New York State, please see the general information section of the Cornell Guide for Integrated Field Crop Management. Detailed soil survey maps are available through local Cornell Cooperative Extension, NRCS and SWCD offices. For the soil types in your fields search online: *Web Soil Survey* from USDA-NRCS. After determining whether the soil is suitable, check for perennial weeds, correct pH, and soil nutrient levels before planting.

8.2.1 Soil Health

Soils in good health provide a desirable medium for root development, have pore space for both air and rapid percolation of excess water, have a high water-holding capacity so crops can withstand dry periods, are less prone to erosion, and resist the tendency to crust. Healthy soils have low levels of soil-borne disease organisms, and high levels of beneficial soil organisms. Many agricultural practices cause soil structure to deteriorate. Compaction, which results from the use of equipment on wet soils, is particularly damaging. Tillage tools break down soil aggregates, the tiny, basic building-blocks of good soil structure; intensive cultivation accelerates loss of organic matter and causes soil to crust. Obviously, all unnecessary operations should be avoided. Prepare the soil only enough to provide an adequate seedbed. Never plow, till, plant, or cultivate soils when they are wet. A ball of soil which crumbles when pressed with the thumb is likely dry enough. One mistake can reduce the yield of the crop regardless of the level of other inputs. For detailed information on soil health and the Cornell Soil Health Test: https://soilhealth.cals.cornell.edu.

8.3 Crop Rotation

Vegetable crops within the same plant family (crucifers, legumes, vine crops, Solanaceous crops, etc.) tend to share the same diseases. As a rule of thumb, don't include that plant family more than once every three years in the rotation. Include cover crops in the same family as well.

Rotation with forage, hay, and cereal crops is an effective way to maintain the organic matter and structure of soils used primarily for vegetables. A good stand of legume or grass-legume sod can also provide substantial nitrogen upon decomposition, thus reducing the nitrogen fertilizer requirement for the next vegetable crop planted. Grass and/or legume sods have a place in the rotation to maintain the porosity of fine-textured soils, improve the water-holding capacity of coarse soils, and may reduce the buildup of disease, insect, and weed pests. Note: All legumes, whether crops or cover crops, share many of the same diseases.

8.4 Cover Crops

Cover crops are planted to protect and improve the soil, suppress weeds and diseases, and help cycle nitrogen. Integrating cover crops into vegetable production systems offers many benefits, but provides some challenges as well. For cover cropping to be successful, it is important to know the intended purposes, consider key management factors, and understand the characteristics of different cover crop species.

Cover crops offer a way to add organic matter to soils; improve soil tilth and reduce compaction; protect soil from wind and water erosion; add or recycle plant nutrients; increase the biological activity of soil; retain soil moisture; and in some cases, suppress weeds and diseases. No single cover crop can do all of these things. Matching the need and opportunity to the right cover crop requires information and planning.

Cover crops need to be treated with the same care as cash crops in order to get the intended value. The best success will come with practices that favor a fast start, and that leave no gaps in the stand. These include: sufficient temperature, soil moisture, and soil fertility; practices such as preparing an adequate seedbed by drilling seed or broadcasting and cultipacking; inoculating legume seed with the proper *Rhizobium* inoculant; and, correcting pH or soil fertility problems. In some cases escaped weeds must be controlled with herbicides or by mowing the cover crop in midseason.

Cover crops must also be killed on time. Before planting, know when and how the cover crop will be killed, and have access to the means of termination. Cover crops that are killed too soon don't deliver the benefit for which they were planted. If killed too late, they can reseed, leave clumps that

8.9 Soil pH

In general, vegetable crops grown on mineral soils will thrive at pH 6.0 to 6.5. Some vegetables do well at pH 5.5; potatoes will tolerate even greater acidity. In contrast to mineral soils, the desirable pH for muck soils is approximately 5.5, and they should not be limed above pH 5.7. This is largely because of the much greater amounts of calcium found in muck at pH 5.5 compared to mineral soils at similar pH. Specific pH ranges for individual vegetable crops are given under each crop's fertility section.

When soil pH is adequate, the availability of both major and minor nutrients is maximized, and the accumulation of toxic metals is minimized. Clearly, one cannot expect to maximize dollars spent for nitrogen, phosphorus, and potassium fertilizer when soil pH is suboptimal. Thus, many people consider soil pH to be the most important part of the soil test.

For optimal vegetable production on New York's acidic soils, soil pH should be adjusted with lime to fit the needs of the various crops. When soil pH is 6.0 or below, the laboratory will determine the exchangeable acidity on the sample. A lime requirement can be determined based on pH (actual acidity of the soil solution) and exchangeable acidity (reserve acidity for that soil). Two soils with the same low pH reading could require markedly different amounts of lime to correct the situation. A given amount of lime could overlime one soil, causing problems that did not exist previously, whereas the same amount of lime might be insufficient to correct the undesirable acidity in the other soil. This is one reason soil testing is so important.

Based on exchangable acidity, as determined by the soil test, an accurate lime recommendation can be given. When complete soil tests are not available, the general lime recommendations in Table 8.9.1 may prove useful. The lime rates given are based on an eight inch plow depth. If the plow depth is less than eight inches, decrease the rate given in the tables by 12 percent for every inch less than eight inches. If the plow depth is more than eight inches, increase the lime rate given by 12 percent for every inch greater than eight inches. For example, a plow depth of ten inches and a lime recommendation of four tons would require 24 percent more lime than given in the table. Therefore, the total rate to apply is approximately five tons (4 tons multiplied by 1.24 = 4.96).

The lime recommendations given in Table 8.9.1 and on the soil test result form are for limestones of 100 percent Effective Neutralizing Value (E.N.V.). These rates need to be increased or decreased according to the actual E.N.V. of the limestone being applied. The rate to be applied is calculated by dividing the recommended rate given in the tables or the test report (if necessary, correct for plowing depth) by the E.N.V. of the lime to be used. For example, if the recommended lime rate is four tons per acre and the E.N.V. of the limestone to be spread is 0.68, the rate to apply would be 5.88 tons (4.0 divided by 0.68), which would round off to six tons per acre. The delivery slip accompanying bulk spread limestone specifies the E.N.V. and the quantity required to equal limestone at 100 percent E.N.V.

Limestones vary in E.N.V. because of differences in purity (calcium carbonate equivalence) and particle size. Coarse limestone or limestone of lower purity is less effective than is more finely ground limestone or limestone of higher purity in neutralizing soil acidity. Cost per ton can be misleading if the limestones being compared do not have a similar E.N.V. Accordingly, the least expensive lime in terms of dollars per ton may not be the best value.

Table 8.9.1 General lime recommendations to raise pH to 6.5 for vegetables other than potatoes.[1]

	Sands	**Sandy loams**	**Loams and silt loams**	**Silty clay loams**
Initial soil pH	*(Values given in Tons/acre)*			
4.5	4.0	7.0	12.1	15.0
4.6 to 4.7	3.5	6.5	10.0	13.0
4.8 to 4.9	3.0	6.0	9.0	12.5
5.0 to 5.1	2.5	5.5	8.5	12.0
5.2 to 5.3	2.0	4.5	6.5	8.0
5.4 to 5.5	1.5	3.0	4.0	6.0
5.6 to 5.7	1.0	2.0	3.0	5.5
5.8 to 5.9	0.8	1.8	2.5	3.5
6.0 to 6.1	0.6	1.5	2.0	3.0
6.2 to 6.3	0.5	1.0	1.5	2.5
6.4 to 6.5	0.3	0.8	1.3	2.0

[1] A guideline for muck is that 1,000 lb. of lime will raise the pH about 0.1. These rates are based on an 8" plow depth and lime with an effective neutralizing value (E.N.V.) of 100 percent.

Chapter 9 – Transplant Production

9.1 Cultural Practices

Many crops are transplanted in New York because of the late spring, relatively short growing season, and desire to obtain maturity as early as possible. Transplants can be grown in greenhouses, plant beds, or field nurseries operated by vegetable growers or commercial plant growers. A good transplant is healthy, stocky, and relatively young with four to six true leaves. Such plants require uniformly fertile soil or mix, good light, even spacing, and proper temperature and water. Exposure to full sun outdoors or reduced temperature and watering near the end of the growing period toughen the plant and allow it to accumulate food reserves for starting the new root system after transplanting. Tender, very young, or weak plants often die. Overmature or hardened plants usually resume growth slowly and often have reduced yield and smaller fruit. Cabbage, broccoli, cauliflower, celery, and onion plants used for early spring planting may go to seed prematurely or "button" if subjected to cool temperatures during the growing period. Desirable daytime and minimum nighttime temperatures for growing plants and the approximate time required at these temperatures are listed in Table 9.1.1.

The greater the difference between daytime and nighttime temperatures, the more plants appear to "stretch" (stems elongate). For some crops, a stockier, thicker-stemmed plant might be obtained when day and night temperatures are reversed (e.g., 60°F day, 70°F night). We do not have enough data to recommend this approach, but growers may wish to experiment on a small scale.

Excellent plants can be grown in flats or cell or plug trays either by direct seeding or the conventional seed-plant flat combination. Seeding directly often reduces growing time and labor costs and can produce 25 percent more plants per flat. Seed can be planted by hand in rows or spots or broadcast and later thinned to the desired spacing. Reasonably good seed spacing can be obtained using a vacuum-operated seed-spotting tank built to the dimensions of the flats or cell trays. For tomatoes, peppers, and eggplant, wide spacing of 16 plants per square foot in the flat can lead to stocky plants that produce high early yields. Close spacing of 48 to 72 plants per square foot leads to more slender, wiry, less expensive plants. Although their early production is light, these plants usually give high total yields, which are desirable for processing and for late-market crops.

9.2 Growing Media

9.2.1 Soil

A good soil is characterized by at least four percent organic matter to give it good structure; medium texture (fine sandy loam or silt loam); medium to good fertility level; low soluble salts; pH of 6.0 to 6.8; and freedom from diseases and pests. Sufficient phosphorus (about two pounds of 0-20-0 per cubic yard) must be mixed thoroughly and uniformly with the soil. A soil test should be run well before use of any soil or compost, so necessary corrections in soluble salts, pH, and fertility levels can be made. Soluble salts should be kept below a K x 10^5 reading of 100 to 125, although muck soils can tolerate a somewhat higher amount without injury. Leaching and keeping the soil in the flat moist are partial solutions for high soluble salt problems. Refer to Section 9.6.1 for information on soil sterilization and control of diseases.

9.2.2 Artificial Mixtures

The artificial mix formula listed in Table 9.2.1 has proved practical for all vegetable plants. This mix is lightweight, does not crust, holds water well, and does not require sterilization.

Fertilizers should be spread evenly over the peat and vermiculite. Two ounces of nonionic water wetter, such as Aquagro, in ten to 20 gallons of water per cubic yard help to wet the mix. Mix the ingredients thoroughly on a clean floor or in a concrete mixer. Fill the flats, packs, or pots, and water thoroughly; wait approximately 15 to 30 minutes and water again. Transplant seedlings or sow seed in mixture. Do not plant too early because plants grow rapidly in the mix. For information on planting dates, see Section 9.5. In flats with transplants, apply a soluble fertilizer (one pound per 100 gallons of water) approximately three weeks after thinning or transplanting, and repeat once or twice a week. Calcium nitrate works well for this purpose.

Table 9.1.1 Temperature requirements for plant production. (Temperature values are given in °F).

Crop	Day Temperature	Night Temperature	Weeks from seed
Broccoli, Cabbage, Cauliflower	65	55-60	4-6
Celery	65	60	8-12
Eggplant	70-80	60	6-8
Lettuce	60-65	50	3-5
Melons	70-75	60	2-3
Onions	65-70	55-60	6-8
Pepper	70-75	60	6-8
Tomatoes	65-70	60	5-8

Chapter 10 – Postharvest Handling

10.1 Background

Vegetables and fruit are living organisms that continue to change after harvest. While some of these changes are desirable, most are not, and growers must be aware of effective ways to minimize undesirable changes, increase shelf life, minimize food safety risks and decrease postharvest losses. For most vegetables, maintaining cool temperatures and high humidity are the most effective means of preserving quality.

Once picked, vegetables will respire, meaning they use their stored sugars to produce carbon dioxide and heat. The more rapid the rate of respiration, the faster a vegetable will use up the stored food supply; the greater the heat produced, the shorter the postharvest life of a given commodity.

Vegetables also give off ethylene, a ripening hormone which promotes senescence. Detrimental effects of senescence include loss of green color; abscission of leaves or flowers; toughening of asparagus spears; russet spotting in lettuce; sprouting of potatoes; bitterness in carrots; and general weakening of the vegetable, which greatly reduces the natural resistance to decay organisms. The effect of ethylene is influenced by the amount present, the length of time the vegetable is exposed, and the temperature. Exposure to a specific concentration of ethylene for a given time will have much less influence at 32°F than at 85°F. The sensitivity of many vegetables to ethylene increases with maturity or age.

Transpiration, the loss of moisture from living produce, is one of the primary determinants of postharvest life and quality. The rate of moisture loss depends on both the commodity and the environment and is influenced by many physical and morphological factors. These factors include storage environment, surface to mass ratio (e.g., leaf lettuce has much more surface area per weight than winter squash and is more subject to weight loss), and injury. High humidity also helps to limit moisture losses. See specific crop chapters for best storage temperature and humidity recommendations.

10.2 Harvest Considerations

Harvesting tools, equipment, and containers, must be cleaned and sanitized, when possible, before harvest begins and anytime they become dirty. Cleaning tools, detergents, and sanitizers must be provided so sanitation practices can be completed. Workers and visitors who contact vegetables and/or food contact surfaces, also must have clean hands. Well-stocked and clean toilet and handwashing facilities must be provided to all employees and any visitors. Employees must be trained on how to properly wash their hands as well as when handwashing is critical, such as after using the toilet, after eating, and anytime they may be contaminated due to contact with animal or other sources of illness causing organisms.

10.3 Clean Surfaces and Containers

Dirty surfaces can also transmit decay and illness causing organisms, Ensuring harvest and postharvest tools and containers are clean and sanitized prior to use will reduce both postharvest losses and food safety risks. If new containers are used, ensure they are stored in clean areas prior to use to prevent contamination. The concern about clean surfaces extends to the hands of those involved in post-harvest handling such as those who cull and pack produce. Proper hand hygiene including handwashing will reduce food safety risks that could be introduced during postharvest handling.

10.4 Washing and Chlorination

Decay is usually the most obvious postharvest problem but food safety risks should also be a consideration. Many decay and illness causing organisms (bacteria and fungi) cannot invade sound, undamaged tissue, but as the tissue becomes older, it becomes weaker and more subject to invasion. To control postharvest losses and reduce food safety risks, it is recommended that produce be washed in chlorinated water before storage or shipping (see Table 10.4.1). The wash temperature should be about 10°F warmer than the produce temperature to ensure that decay and illness causing organisms are not sucked into the tissue. Since chlorine is most effective at a slightly acidic pH, it is important that wash water is buffered to adjust the pH to between 6 and 7.

Table 10.4.1. Amount of sodium hypochlorite to add to wash water for 50 - 150 PPM dilution.

Target PPM	ml/L	Tsp/5 gal	Cup/50 gal
	Sodium Hypochlorite, 5.25%		
50	1.0	3 2/3	¾
75	1.4	5 ½	1
100	1.9	7 ¼	1 ½
125	2.4	9	2
150	2.9	11	2 ¼
	Sodium Hypochlorite, 12.75%		
50	0.4	1 ½	1/3
75	0.6	2 ¼	½
100	0.8	3	3/5
125	1.0	3 ¾	4/5
150	1.2	4 1/2	1

Chlorine in the wash water is often inactivated when the wash water becomes dirty. Use filtering devices to remove soil and organic material, and check the chlorine concentration often. Produce should be subjected to the chlorinated wash from one to ten minutes. After it is removed, allow it to drain for several minutes before packing. There are other chemicals beside chlorine that can be used such as those that are peroxide or peroxyacetic acid based. Whatever is used, it should be labled for use on vegetables.

Chapter 11 – Organic Vegetable Production

11.1 Organic Certification

To use a certified organic label, farming operations that gross more than $5,000 per year in organic products must be certified by a U.S. Department of Agriculture National Organic Program (NOP) accredited certifying agency. The choice of certifier may be dictated by the processor or by the target market. A list of accredited certifiers operating in New York is compiled on the New York State Department of Agriculture and Markets Organic Foods and Farming pages: https://agriculture.ny.gov/farming/organic-foods-and-farming. See more certification and regulatory details under Section 11.4.1 *Certification Requirements* and Section 11.7: *Using Organic Pesticides*.

11.2 Organic Farm Plan

An organic farm plan is central to the certification process. The farm plan describes production, handling, and record-keeping systems, and demonstrates to certifiers an understanding of organic practices for a specific crop. The process of developing the plan can be 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.

More details may be found at: the Agricultural Marketing Service's National Organic Program website (https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program).

11.3 Soil Health

Healthy soil is the basis of organic farming. Regular additions of organic matter in the form of cover crops, compost, or manure create a soil that is biologically active, with good structure and capacity to hold nutrients and water (note that any raw manure applications should occur at least 120 days before harvest). Decomposing plant materials will activate a diverse pool of microbes, including those that break down organic matter into plant-available nutrients as well as others that compete with plant pathogens on the root surface.

Rotating between crop families can help prevent the buildup of diseases that overwinter in the soil. Rotation with a grain crop, preferably a sod that will be in place for one or more seasons, deprives many disease-causing organisms of a host, and also contributes to a healthy soil structure that promotes vigorous plant growth. The same practices are effective for preventing the buildup of root damaging nematodes in the soil, but keep in mind that certain grain crops are also hosts for some nematode species. Rotating between crops with late and early season planting dates can help prevent the buildup of weed populations. Organic growers must attend to the connection between soil, nutrients, pests, and weeds to succeed. An excellent resource for additional information on soils and soil health is Building Soils for Better Crops, 3rd edition, by Fred Magdoff and Harold Van Es, 2010, available from SARE, Sustainable Agriculture Research and Education: https://www.sare.org/resources/building-soils-for-better-crops-3rd-edition/ For more information, refer to the Cornell Soil Health website (http://soilhealth.cals.cornell.edu/).

11.4 Cover Crops

Unlike cash crops, which are grown for immediate economic benefit, cover crops are grown for their valuable effect on soil properties and on subsequent cash crops. Cover crops help maintain soil organic matter, improve soil tilth, prevent erosion and assist in nutrient management. They can also contribute to weed management, increase water infiltration, maintain populations of beneficial fungi, and may help control insects, diseases and nematodes. To be effective, cover crops should be treated as any other valuable crop on the farm, carefully considering their cultural requirements, life span, mowing recommendations, incorporation methods, and susceptibility, tolerance, or antagonism to root pathogens and other pests. Some cover crops and cash crops share susceptibility to certain pathogens and nematodes. Careful planning and monitoring is required when choosing a cover crop sequence to avoid increasing pest problems in subsequent cash crops. "Crop Rotation on Organic Farms: A Planning Manual" (https://www.sare.org/resources/crop-rotation-on-organic-farms/) is a valuable resource for optimizing your rotations. See Section 11.6: *Crop and Soil Nutrient Management* for more information about how cover crops fit into a nutrient management plan.

A certified organic farmer is required to plant certified organic cover crop seed. If, after contacting at least three suppliers, organic seed is not available, then the certifier may allow untreated conventional seed to be used. Suppliers should provide a purity test for cover crop seed. Always inspect the seed for contamination with weed seeds are two key components required for applying an accurate pesticide dose per acre. Applying too much pesticide is illegal, can be unsafe and is costly whereas applying too little can fail to control pests or lead to pesticide resistance.

Resources:

- Chapter 6: Pesticide Information and Use
- Calibrating Backpack Sprayers – pesticidestewardship.org/calibration/Pages/BackpackSprayer.aspx
- Pesticide Environmental Stewardship calibration pages – pesticidestewardship.org/calibration/

11.8.2 Regulatory Considerations

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

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

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

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

Do you need to be a certified pesticide applicator? The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) defines two categories of pesticides: general-use and-restricted use. NYS DEC also defines additional restricted-use pesticides. Pesticide applicator certification is required to purchase and use restricted-use pesticides. Farmers who purchase and use only general-use pesticides on property they own or rent do not need to be certified pesticide applicators. However, we do encourage anyone who applies pesticides to become certified. Find more information on pesticide applicator certification from the list of State Pesticide Regulatory Agencies or, in New York State, see the Cornell Cooperative Extension Pesticide Safety Education Program (CCE-PSEP) website at psep.cce.cornell.edu.

Worker Protection Standard training. If the farm has employees who will be working in fields treated with a pesticide, they must be trained as workers or handlers as required by the federal Worker Protection Standard (WPS). Please see Section 6.8 in Chapter 6 for more details on the WPS.

11.8.3 Pollinator Protection

Honey bees, wild bees, and other insects are important for proper pollination of many crops. Poor pollination results in small or odd-shaped fruit as well as low yields. Please see section 6.3 in Chapter 6 for more information on protecting pollinators.

11.8.4 Optimizing Pesticide Effectiveness

Information on the effectiveness of a particular pesticide against a given pest can sometimes be difficult to find. Some university researchers include pesticides approved for organic production in their trials; some manufacturers provide trial results on their web sites; some farmers have conducted trials on their own. The Resource Guide for Organic Insect and Disease Management and Cornell organic crop production guides provide efficacy information for many approved materials.

In general, pesticides allowed for organic production may kill a smaller percentage of the pest population, could have a shorter residual, and may be quickly broken down in the environment. Read the pesticide label carefully to determine if water pH or hardness will negatively impact the pesticide’s effectiveness. Use of a surfactant may improve organic pesticide performance. Search the OMRI Products List for NOP-compliant adjuvants. 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.

Chapter 13 – Beans – Dry, Snap, and Lima

13.1 Varieties

See Disease Resistant Bean Varieties at: https://www.vegetables.cornell.edu

13.2 Planting Methods

Most dry beans should be planted between May 20 and June 30, but light red kidneys and cranberry beans can be planted as late as July 10, due to their earlier maturity date. Insecticide-fungicide seed treatments assist early dry bean plantings, but best germination occurs at soil temperatures of 60°F or above. When weather and soil conditions permit, late-May and early-June plantings often yield as much or more than plantings made in mid-June or later. Optimal germination of snap bean seed occurs at soil temperatures of 75°F to 80°F. The minimum temperatures at which snap bean germination will occur are 55°F to 60°F. For recommended spacing of dry and snap beans, see Table 13.2.1. Bean seed is sensitive to chilling during the initial stage of germination, which is referred to as imbibition. If the soil is cold at this time, permanent damage may occur. If, however, imbibition occurs under warm conditions, the seed can later tolerate cool soil temperatures and still germinate normally. The most critical period is the first 24 hours after planting. Seed with low vigor is especially sensitive to chilling injury, and dry seed is injured more easily than seed with a higher moisture content. Increasing the moisture content of the seed by placing it in an environment of high relative humidity for several days before planting can help minimize injury.

Planting dates for fresh-market and processing snap beans are May 1 to July 25. The crop matures in 50 to 60 days, depending on the specific variety and desired pod size. Only western-grown, certified, dry and snap bean seed should be planted.

A good rotation helps reduce the incidence of foliar diseases and lowers the population of plant pathogens that cause root rot and other diseases. Corn and cereal grains are excellent rotation crops. If a field with a history of root rot is to be planted to beans, plant as late as possible in the season when the soil is warm. To allow for adequate aeration and drainage of excess moisture, avoid compacting the soil. Planting on raised beds or ridges will help reduce root rot severity because the soil will be warmer and drier than the unridged soil. Seed should be treated with recommended fungicides.

Dry beans are not usually irrigated because of the lower cash value of the crop relative to the cost for irrigation. Nevertheless, one or two well-timed irrigations near blossom set and early pod fill can increase yields significantly if the crop is undergoing drought conditions.

A deficiency of water in the plant resulting from a lack of soil moisture or excessive transpiration can lead to deformed or pithy snap bean pods. Both yield and quality can be increased by irrigation before bloom and during pod enlargement if there is moisture stress. Irrigation during bloom with irrigation guns that produce large droplets is not advised because blossoms can be knocked off the plant.

13.3 Fertility

Use lime to maintain a pH of 6.0 to 6.5. See Table 13.3.1 for the recommended rates of nitrogen, phosphorus, and potassium.

13.4 Harvesting

All processing and most fresh-market snap bean acreage is harvested by machine. Processing snap beans are prepared relatively soon after harvest. Fresh-market beans can be held for about one week at 40° to 45°F and 90 to 95 percent relative humidity.

Dry beans should be harvested when the plants reach physiological maturity. If maturity is uneven, several chemical defoliants are available to speed-up the dessication of plants and pods. See Table 13.4.1. Do not delay the harvest after the beans become mature because fall rains on mature beans cause sprouted or blemished seed. Beans darken rapidly in the field after they are mature and subsequently become unmarketable. All varieties must be threshed carefully to prevent checked skins or broken seeds. Seed damage at harvest is highly correlated with low seed moisture and is least likely if moisture is 16 to 20 percent. At harvest time, beans undergo many drying and rewetting processes daily. The threshing cylinder on the combine should be adjusted frequently to minimize seed damage.

Table 13.2.1 Recommended spacing of dry and snap beans.

Type of bean	Row (in inches)	In-Row (plants/foot)	Comments
Dry	28-32”	4-6	Because seed size varies greatly between varieties, make sure the proper amount is planted. Red kidney classes require 75 to 100 pounds per acre, whereas black turtle soup and navy/pea beans run at 35 to 40 pounds per acre. Adjust the plant rate for the percentage of germination.
Snap	30-36”	5-7	If closer row spacing and a higher plant population per acre is used, a proportionately higher rate of fertilizer should be applied.

Dry beans should be handled as carefully and as little as possible after harvest to reduce damage. Use inclined chutes, belts, or bucket conveyors to move seeds, but avoid augers or free fall drops. Because checking and cracking of seed coats increases during handling as moisture content drops below 18 percent and rot problems are greater when moisture is higher, beans should be dried to between 17 and 18 percent for storage. If a mechanical drier is used, care must be taken not to dry the seed too quickly or the beans can be damaged.

Table 13.3.1 Recommended application rate of nutrients based on soil tests.[1,2]

N (pounds/acre)	P_2O_5 (pounds/acre)			K_2O (pounds/acre)			Comments
	Soil Phosphorus Level			Soil Potassium Level			
	low	med.	high	low	med.	high	
40[3]	***80***	***60***	***40***	***60***	***40***	***20***	***Total recommended***
0	0	0	0	20	0	0	Broadcast and disk-in.
40[4]	80	60	40	40	40	20	Band place with planter.

[1] If pH is <5.5, as in rotations with potatoes, or if the magnesium soil test is <30, apply 5 pounds per acre magnesium in the band at planting.
[2] If pH is 7 or higher, include 1 pound per acre of zinc and manganese in the band at planting. After moderate or heavy applications of lime, when fields have been newly tilled, or when erosion has occurred exposing calcareous subsoil, apply 2 pounds per acre of zinc and manganese.
[3] If dry beans follow a well-established legume cover crop, apply only 20 pounds per acre of nitrogen.
[4] If nitrogen deficiency is likely because of leaching rains, apply 30 pounds per acre when plants have 2 or 3 true leaves.

Table 13.4.1 Compounds for defoliation of dry beans.

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
Valor SX (*flumioxazin*) (Group 14)	1.5-2 oz	5	12	1.0-1.4	*See comments below.*
Do not exceed 3 oz per acre per season. Use requires the addition of an agronomically approved adjuvant to the spray mixture. A methylated seed oil (MSO) or crop oil concentrate can be used in conjunction with a spray grade nitrogen source to enhance desiccation. See label for details.					
Roundup, Touchdown Total, or OLP (*glyphosate*) (Group 9)	See label	7	See label	Varies with rate. See EIQ link to calculate	*See comments below.*
Apply when there are no green leaves visible and when the beans are in the hard dough stage (30% or less grain moisture). Should not be used on crops grown for seed.					
Defol 750L (*sodium chlorate*)	3.2 qts	7	12		*See comments below.*
Vine defoliation can be accomplished by using the recommended rate in 5 to 10 gallons of water by air application or 10 to 20 gallons of water by ground equipment. Thorough coverage is essential. Make application 7 to 10 days before harvest, longer if temperatures are below 60°F. Beans must be at least 75 percent physiologically mature at time of treatment or yield and quality may suffer. To determine maturity, scratch off the seed coat from the bean seed. If it is white or pink underneath, it is mature; if it is green, it is immature. Do not graze treated fields or feed treated fodder to livestock.					
*†Sharpen (*saflufenacil*) (Group 14)	1.0-2.0 fl oz	2	12	0.4-0.8	*See comments below.*
Apply when beans have at least 80% yellow/brown pods and no more than 30% green leaves for vine type beans and 40% green leaves for bush type beans. Thorough coverage and a methylated seed oil (MSO) plus ammonium-based adjuvant system required for optimum desiccation. Allow up to 7 days for optimum desiccation depending on environmental conditions.					

* Restricted-use pesticide † Not for use in Nassau/Suffolk Counties

14.5.2 Pocket rot and Rhizoctonia stem canker, crown rot, or wirestem. *(continued)*

Management Option	*Guideline*
Seed selection/treatment	Plant vigorous, disease-free seed, and ensure it has been treated with Apron plus thiram and/or Maxim.
Cultivation	To reduce disease severity, minimize the amount of soil thrown on crown tissues during cultivation.
Postharvest	If possible, crop debris should be destroyed as soon as possible to remove this source of disease for other plantings and to initiate decomposition.
Sanitation	This is not currently a viable management option.

Compound(s) Pocket rot and Rhizoctonia stem canker

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
Quadris Flowable (*azoxystrobin*) or OLP (Group 11)	0.4-0.8 fl oz/1000 row feet	0	4	Not Available	Rhizoctonia stem canker or crown rot, and Pythium root rot. *EIQ: 63.00*

14.5.3 Seed rot, damping-off, and root rot.

This disease complex is primarily caused by *Pythium ultimum* and *Rhizoctonia solani*, however *Aphanomyces cochlioides* and *Phoma betae* also occur on beets.

Time for concern: Planting through the end of the season, therefore long term planning is required for sustainable management.

Key characteristics: Poor emergence, uneven growth, dead seedlings, wire-stem symptoms on seedlings, and reddish discoloration of aboveground plant parts appear in patches and low spots. Plants infected with Rhizoctonia develop abnormal, fleshy roots with constrictions and rotted areas of various shapes and sizes. In mature plants**,** pocket rot appears first as black cankers on the lower petioles and the crown area as well as dry, black-rotted portions of the fleshy beets. Lesions may also be found on leaves and petioles. The seedlings that survive early infection generally develop and have diseased roots. In some cases, disease may only be seen as a postharvest decay. See the Cornell Vegetables Rhizoctonia Crown and Root Rot of Table Beet and Phoma Leaf Spot and Root Rot of Table Beet fact sheets.

Management Option	*Guideline*
Scouting/thresholds	Record the occurrence and severity of seed and root rot diseases and of pocket rot for future crop rotation planning purposes. Thresholds are not applicable.
Resistant varieties	Red Ace exhibits lower Rhizoctonia levels. No varieties are resistant to seed rot, damping-off and root rot.
Crop rotation	Rotate out of vegetables with nonhost crops such as grains. Rhizoctonia attacks most vegetables and has a broad host range.
Site selection	Sites that are well-drained with healthy soil and good soil structure are preferred. Avoid soil compaction and crusting. To reduce disease severity, minimize the soil thrown on crown tissues during cultivation.
Seed selection/treatment	Plant seed treated with Apron or Allegiance (similar active ingredient) plus Thiram and/or Maxim. The combination of Thiram plus Apron is effective during cool, wet weather when *Pythium* is a problem. Apron is highly effective against *Pythium*; Thiram provides protectant activity against a broad spectrum of fungi, but especially *Phoma*. Maxim and Captan are also available as seed treatments in combination with Apron and Thiram. Maxim has activity against *Rhizoctonia*, *Fusarium* and *Phoma*.
Postharvest	If possible, plow under infected crop debris to remove this source of disease for other plantings and to initiate decomposition.
Sanitation	Not a viable option.

15.6 Insect Management

15.6.1 Cabbage root maggot, *Delia radicum*

Time for concern: April through July. Several weeks after transplanting

Key characteristics: The cabbage root maggot is a small, white, legless worm with a blunt end that grows about 1/4 inch in length. Look for brown tunnels in stems and roots. See Cabbage Maggot fact sheet from Wisconsin.

Management Option	***Guideline***
Scouting/thresholds	A degree-day model to predict the flight periods of cabbage root maggot adults can help growers manage this pest. Forecasts of the flight periods for your area can be obtained through the NYS IPM program's Network for Environmental and Weather Applications (newa.cornell.edu/cabbage-maggot) . A general guideline for time of occurrence is to note the flowering period for some wild plants. Research has shown that Yellow Rocket roughly correlates with the first brood adult emergence, Day Lily with the second brood, Canada Thistle and Goldenrod with the third brood, and New England Aster with the fourth brood. Growers may want to apply an insecticide if planting occurs close to an adult peak.
Note(s)	Cabbage maggot eggs can be killed if soil temperatures are above 95°F for several days. During May and June, these temperatures will often be reached unless soil moisture is high due to rains. Chinese cabbage is often attacked by a bacterial disease, soft rot, caused by the pathogen *Erwinia carotovora*. While entry of the pathogen can be caused by cultivation and other non-biological factors, cabbage and seed corn maggots can also be culprits. Injury first occurs on the white petioles at the base of the plant through an entry wound. Directed insecticide applications near the base will help prevent entry of the pathogen. Once infected, the disease will rapidly progress and cause the plants to degrade and smell terribly. Heavy soils tend to produce more soft rot due to their high water holding capacity compared to sandy, light textured soils; however, it can occur on both. Suggestions for reducing damage include: 1) grow for a spring/summer crop; 2) grow summer crops on raised beds and trickle irrigation to minimize the presence of free water; 3) carefully monitor for any insect or diseases that may compromise the plant and predispose it to infection by *E. carotovora.*
Resistant varieties	No resistant varieties are available, but all varieties become more tolerant of injury after seedling stage. Broccoli and cauliflower are more susceptible than cabbage or Brussels sprouts.
Natural enemies	Cabbage maggot eggs and small larvae are subject to predation by rove beetles and other ground dwelling predators. *Aleochara bilineata*, a rove beetle, is both a predator and parasite of root maggots. See the Cornell Biocontrol web site for identification of natural enemies. Some experiments have demonstrated that entomopathogenic nematodes can reduce populations of cabbage maggot if applied at high concentrations.
Spunbonded row covers	Spunbonded row covers can control cabbage maggots. At time of seeding, place in the field and seal the edges to keep cabbage maggots out. The yields of late plantings may be reduced by row covers. It is important to make use of crop rotation when using row covers. Otherwise, flies may emerge under the row covers and damage the crop.
Crop rotation	Rotation will help reduce root maggot populations.
Site selection	Soils with high organic matter content are more conducive to cabbage maggot infestations. Decomposing organic matter seems to attract egg laying adults. Leave at least 2 to 3 weeks after plowing under a cover crop before planting any brassica crops.
Postharvest	Crop debris should be destroyed as soon as possible after harvest to minimize the spread of cabbage root maggots.
Sanitation	This is not a currently viable management option.

Compound(s) Cabbage root maggot

Product Name (Active Ingredient) (Class of Compounds)	**Product Rate**	**PHI (Days)**	**REI (Hours)**	**Field Use EIQ**	**Comments**
*Capture LFR (*bifenthrin*) (Group 3A)	3.4-6.8 fl oz/acre	7	12	2.6 - 5.3	Direct-seeded crops only. Apply in a 5-7 inch band in furrow.

Table 17.5.2 Relative effectiveness of various chemicals for cucurbit disease control. *(continued)*

		Relative Control Rating												
Trade Name (*active ingredient*) and Group Number(s)	PHI (days)	Alternaria Blight	Bacterial Leaf Spot	Anthracnose	Belly Rot	Cottony Leak	Damping Off	Downy Mildew	Gummy Stem Blight	Plectosporium Blight	Phytophthora Blight	Powdery Mildew	Scab	Septoria Leaf Spot
phosphorous acid [b], 33 Phostrol, ProPhyt or OLP	0	-	-	-	-	-	-	+	-	-	++	-	-	-
*Presidio (*fluopicolide*) 43	2	-	-	-	-	-	-	V/R	-	-	+++	-	-	-
*Previcur Flex (*propamocarb*) 28	2	-	-	-	-	-	-	+++/R	-	-	-	-	-	-
Pristine (*pyraclostrobin + boscalid*) 11 + 7	0	+++	-	+++	-	-	-	R	R	+	-	R	-	+
*Procure (*triflumizole*) 3	0	-	-	-	-	-	-	-	-	-	-	+++C R	-	-
Proline (*prothioconazole*) 3	7	-	-	-	-	-	-	-	+++	-	-	++++ CR	-	-
Prolivo (*pyriofenone*) 50	0	-	-	-	-	-	-	-	-	-	-	++	-	-
Quadris F (*azoxystrobin*) 11	1	+++	-	+++	+++	-	-	R	R	+++	-	R	-	+
Quadris Opti (*azoxystrobin + chlorothalonil*) 11 + M5	1	+++	-	+++	+++	-	-	R	+R	+++	-	R	++	++
Rally (*myclobutanil*) 3	0	-	-	-	-	-	-	-	-	-	-	+CR	-	-
Ranman or OLP (*cyazofamid*) 21	0	-	-	-	-	-	-	++++	-	-	+++	-	-	-
*†Reason (*fenamidone*) 11	14	+++	-	-	-	-	-	R	-	-	-	-	-	-
Revus (*mandipropamid*) 40	0	-	-	-	-	-	-	V/**R**	-	-	+++	-	-	-
†Rhyme (*flutriafol*) 3	0	-	-	-	-	-	-	-	++	-	-	++CR	-	-
Ridomil Gold SL, Ultra Flourish (*mefenoxam*) 4	0	-	-	-	-	++	++	R	-	-	+++R	-	-	-
Ridomil Gold Bravo (*mefen-oxam +chlorothalonil*) 4 + M5	0	-	-	M	-	M	-	R	M	M	-	-	M	M
Ridomil Gold Copper (*mefenoxam + copper*) 4+ M1	5	-	-	M	-	M	-	R	-	-	-	-	M	M
Ridomil Gold MZ (*mefenoxam + mancozeb*) 4 + M3	5	-	-	M	-	M	-	R	-	-	-	-	-	-
Sovran (*kresoxim-methyl*) 11	0	-	-	-	-	-	-	-	-	-	-	R	-	-
Sulfur [c] M2	0	-	-	-	-	-	-	-	-	-	-	+++P	-	-
†Switch 62.5WG (*cyprodinil + fludioxonil*) 9 + 12	1	-	-	-	-	-	-	-	++++	-	-	+	-	-
Tanos (*famoxadone + cymoxanil*) 11 + 27	3	+++	-	+++	-	-	-	++	-	-	-	-	-	-
Torino (*cyflufenamid*) U6	0	-	-	-	-	-	-	-	-	-	-	R	-	-
Topsin M or OLP (*thiophanate-methyl*) 1	0	-	-	+	+C	-	-	-	+C,R	-	-	R	-	+C
Vango WG (*cyprodinil*) 9	1	+++	-	-	-	-	-	-	+++	-	-	L	-	-
Vivando (*metrafenone*) 50	0	-	-	-	-	-	-	-	-	-	-	++++ C	-	-
*†Zampro (*ametoctradin and dimethomorph*) 45 + 40	0	-	-	-	-	-	-	++++	-	-	+++	-	-	-
*Zing! (*zoxamide + mancozeb*) 22 + M5	0	M	-	M	-	-	-	++++	M	-		-	-	-

Figure 20.1 Onion grower report form.

Scouting instructions

Onion thrips:

Count thrips on each plant, total across all plants, and divide by the average number of leaves per plant.

Botrytis leaf blight (BLB):

Scout 15 plants and compare the total number of lesions with the upper and lower limits. If below the lower limit, the field is below threshold. If over the upper limit, the field is over threshold. If between the upper and lower limits scout five more plants and compare with the 20 plants line. Repeat until a decision is reached, or 35 plants have been scouted without a decision based on sequential sampling and calculate the number of lesions per leaf.

Other diseases:

For each plant note whether other diseases are present using abbreviations indicated.

Onion IPM Scouting Form

Grower	Field	Date
Cultivar	Crop Stage	
Recommendations: Onion thrips Threshold: 1 per leaf		
Recommendations: Diseases BLB threshold: 1 lestion/leaf		

Plant #	# onion thrips	# BLB lesions / 3 outer leaves	Stemphyllium (SP), downy mildew (DM), purple blotch (PB), smut (SM), bacterial rot (BR), IYSV	# leaves /plant
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
Total				
	÷ lvs/plant	÷105		
Per leaf				

Weed map and notes on onion maggot damage

Total leaves/20 = lvs/plant

Notes:

Sequential sampling for Botrytis leaf blight

Number of plants	Lower Limit	Upper Limit
15	17	73
20	28	92
25	39	111
30	50	130
35	62	148

may be required to cool and dry the tubers. Excessive air flow rates, particularly at low relative humidity, will dehydrate tubers and interfere with the wound healing process. Relative humidity in storage should be as high as possible without causing condensation on the tubers and the storage structure. Good insulation properly protected with a vapor barrier reduces the danger of condensation.

23.4.5 Sprout Inhibitors

Sprout inhibitors should be used in conjunction with good storage management. Although most potato varieties are dormant for two to three months after harvest, they will eventually sprout even in low temperature cold storage. Two chemical sprout inhibitors are available to lengthen the storage period. *Maleic hydrazide* is applied as a field spray on green foliage two to three weeks after the full bloom stage. This material is translocated to the tubers and helps prevent sprouting. *Chlorpropham* (CIPC) is applied as an aerosol through the air ventilation system of the storage facility or as a spray on tubers on the packing line. For specific application rates, see Table 23.4.2. Because the normal warning signal of sprouting will have been suppressed, it is important to examine tubers in the center and at the base of the pile at frequent intervals during the storage season to make sure that storage rots, internal sprouting, or other disorders are not developing. Seed potatoes should not be treated with either material or stored.

Table 23.4.2 Sprout inhibitors

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
Drexel Sprout Stop or OLP (*maleic hydrazide*)	1-1.33 gal/30-150 gal water		12	45.1-60.0/30-150 gal water	*See comment below.*
Apply to growing plants when the smallest tubers are 1.5” in diameter, except for Norchip, which must be at least 2” in diameter. Vines must remain green at least several weeks after application. Allow at least a 2 week interval before use of a vine killer. Do not use on seed potatoes.					
Sprout Nip (*chlorpropham*)	–	–	–	–	*See comment below.*
Apply directly to tubers. Use as a commercially applied aerosol treatment in storage or as an emulsifiable concentrate applied as a spray after washing tubers. Apply after cuts and bruises have healed (2-3 weeks after harvest). Under dosage may increase internal sprouting. Seed potatoes may show delayed sprouting if placed in treated storage, even if all treated potatoes are removed first. Federal law requires that shipping containers are labeled with the chemical name of this inhibitor.					

Table 23.4.3 Nonpathogenic disorders.

Disorder	Management Option	Guideline
Air pollution	Variety selection	Andover and Norland are particularly sensitive varieties.
Hollow heart	Variety selection. Maintain uniform growing conditions	Varieties differ in severity. Avoid growing oversized tubers. Utilize appropriate plant spacing. Irrigate and fertilize for specific variety requirements.
Internal necrosis	Variety selection. Minimize heat stress	Varieties differ in susceptibility. Irrigation reduces soil temperatures and increases calcium uptake.
Blackspot	Avoid bruising tubers Maintain tuber turgor	Minimize impact events during harvesting, transporting, grading, and handling. Store in high humidity and warm before handling operations.
Secondary tubers	Avoid old seed	Purchase good quality seed and keep in cold storage.

Appendix

Table 1. Herbicides mentioned in this publication

Trade Name	Common Name	Formulation	EPA Reg. No.
*†AAtrex 4L	atrazine	4 L	100-497
*†AAtrex NINE-O	atrazine	90 DG	100-585
Accent Q	nicosulfuron	54.5	352-773
Aim EC	carfentrazone	2.0 EC	279-3241
Assure II	quizalofop p-ethyl	0.88 EC	5481-646
Balan	benefin	60 DF	34704-746
Banvel	dicamba	4 L	66330-276
Basagran	bentazon	4 L	66330-413
Basagran 5L	bentazon	5 L	7969-112
Callisto	mesotrione	4 SC	100-1131
Caparol	prometryn	4 L	100-620 (SLN NY-140007)
Chateau EZ	flumioxazin	41.4 SC	59639-221
Chateau SW	flumioxazin	51 WDG	59639-99
Clarity	dicamba	4 EC	7969-137
Command 3ME	clomazone	3 ME	279-3158
Curbit EC	ethalfluralin	3 EC	34704-610
*†Dual Magnum	metolachlor	7.62 E	100-816 and SLN NY-110004
*†Dual II Magnum	metoachlor	7.64 E	100-818
Eptam 7E	EPTC	7 E	10163-283
Formula 40	2,4-D	3.8 L	228-357
†Fusilade DX	fluazifop-butyl	2 EC	100-1070
Goal 2XL	oxyfluorfen	2 E	62719-424
GoalTender	oxyfluorfen	4 F	62719-447
*†Harness Herbicide	acetochlor	7 EC	524-473
Impact	topramezone	2.8 L	5481-524
Karmex DF	diuron	80 DF	66222-51
Kerb SC	pronamide	3.3	62719-578
Laudis	tembotrione	3.5 EC	264-860
Lorox DF	linuron	50 DF	61842-23
Matrix	rimsulfuron	25 DF	352-556
Metribuzin 75	metribuzin	75DF	34704-876
Moxy 2E	bromoxynil	2 E	9779-346
*†Nortron SC	ethofumesate	4SC	264-613 (SLN NY-120014)
*†Optill	saflufenacil + imazethapyr		7969-280
*†Optogen	bicyclopyrone	1.67	100-1465
*†Outlook	dimethenamid-p	6 EC	7969-156
Permit	halosulfuron	75 DF	81880-2-10163
Poast	sethoxydim	1.5 E	7969-58
Prefar 4-E	bensulide	4 E	10163-200
Prowl 3.3 EC	pendimethalin	3.3 EC	241-337
Prowl H2O	pendimethalin	3.8 CS	241-418
*†Pursuit	imazethapyr	2EC	241-310
Raptor	imazamox	1 AS	241-379
*Reflex	fomesafen	2L	100-993 and SLNs NY-130006 and NY-140003
Ro-Neet	cycloate	6L	74530-16
Roundup WeatherMAX	glyphosate	5.5 L	524-537
Sandea	halosulfuron	75 DF	81880-18-10163
*Select Max	clethodim	.97 L	59639-132
*†Sharpen	saflufenacil	2.85WS	7969-278
Sonalan HFP	ethalfluralin	3 EC	10163-356

Table 4. Biopesticides labeled for managing diseases of vegetable crops.

Not all products listed below appear in this publication. Products are broadly labeled for most vegetable crops. Most are labeled for multiple diseases; a few have targeted activity. For more information and crop lists of labeled diseases see www.vegetables.cornell.edu/ipm/diseases/biopesticides/. Most biopesticides are approved for organic production (those with footnote C are not). Most that are approved are OMRI listed. Confirm with certifier before using on organic crop. 25(b) pesticides are exempt from registration.

Trade Name	Common Name	Group Number[A]	Labeled Uses[B]	EPA Reg. No.
PerCarb	sodium carbonate peroxyhydrate	NC	foliar diseases	70299-15
Prestop WG	*Gliocladium catenulatum* strain J1446	NC	seed-borne and soil diseases	64137-13
Problad Verde	Banda de Lupinus albus doce (BLAD)	NC	gray mold, powdery mildew	84876-2
Procidic	citric acid	NC	foliar and damping-off	25(b) pesticide
Promax	thyme oil	NC	soil diseases and nematodes	25(b) pesticide
Rango	cold pressed neem oil	NC	foliar and soil diseases	88760-10
Regalia	extract of *Reynoutria sachalinensis*	P 05	foliar and soil diseases	84059-3
Romeo	Cerevisane (cell walls of *Saccharomyces cerevisiae* strain LAS117)	P 06	foliar fungal diseases	91810-2
RootShield WP	*Trichoderma harzianum* Rifai strain KRL-AG2	BM 02	soil diseases	68539-7
RootShield Plus+ WP	*Trichoderma harzianum* Rifai strain T-22 and *Trichoderma virens* strain G-41	BM 02	soil diseases	68539-9
Seican	cinnamaldehyde	NC	foliar fungal diseases + insects	91473-2-88783
Serenade ASO	*Bacillus subtilis* strain QST 713	BM 02	foliar and soil diseases	264-1152
Serenade Opti	*Bacillus subtilis* strain QST 713	BM 02	foliar diseases	264-1160
Serifel	*Bacillus amyloliquefacinens* strain MBI 600	BM 02	foliar diseases	71840-18
Serifel NG	*Bacillus amyloliquefacinens* strain MBI 600	BM 02	foliar and soil diseases, greenhouse	71840-8
SoilGard	*Gliocladium virens* strain GL-21	NC	soil diseases	70051-3
Sonata	*Bacillus pumilus* strain QST 2808	BM 02	foliar fungal diseases	264-1153
Sporan EC[2]	mixture of botanical oils	NC	foliar diseases	25(b) pesticide
Stargus	*Bacillus amyloliquefacinens* strain F727	BM 02	foliar and soil diseases	84059-28
Taegro 2	*Bacillus subtilis* var. *amyloliquefaciens* strain FZB24	BM 02	foliar and soil diseases	70127-12
Thyme Guard	thyme oil extract	NC	foliar and soil diseases	25(b) pesticide
Thymox Control	thyme oil	NC	foliar fungal diseases	25(b) pesticide
Timorex Act	tea tree oil	46	foliar and soil diseases	86182-3-88783
Triathlon BA	*Bacillus amyloliquefaciens* strain D747	BM 02	foliar and soil diseases	70051-107-59807
Trilogy	extract of neem oil	NC	foliar fungal diseases	70051-2
Zironar	*Bacillus licheniformis* strain FMCH001 and *Bacillus subtilis* strain FMCH002	BM 02	soil diseases and nematodes; sweet corn	279-3618
Zonix Biofungicide	rhamnolipid biosurfactant	NC	diseases caused by Oomycete pathogens	72431-1
Zorda WG	*Bacillus amyloliquefaciens* strain PTA-4838	BM 02	foliar diseases	73049-522

FOOTNOTES:

[A] Group Numbers assigned by Fungicide Resistance Action Committee (FRAC).

[B] 'Foliar' refers to diseases affecting leaves and/or fruit caused by fungal and bacterial pathogens. All soil diseases caused by fungi.

[C] Not approved for organic production.

[D] Phosphorous acid fungicides include *Agri-Fos, Fungi-Phite, Phostrol, ProPhyt, and Rampart.

Tips for Laundering Pesticide-Contaminated Clothing

Pre-Laundering Information

Remove contaminated clothing **before** entering enclosed tractor cabs.

Remove contaminated clothing **outdoors** or in an entry. If a granular pesticide was used, shake clothing outdoors. **Empty pockets and cuffs.**

Save clothing worn while handling pesticides for that use only. Keep separate from other clothing **before, during, and after** laundering.

Wash contaminated clothing after **each** use. When applying pesticides daily, wash clothing **daily**.

Clean gloves, aprons, boots, rigid hats, respirators, and eyewear by scrubbing with detergent and warm water. Rinse thoroughly and hang in a clean area to dry.

Take these **precautions** when handling contaminated clothing:

- Ventilate area.
- Avoid inhaling steam from washer or dryer.
- Wash hands thoroughly.
- Consider wearing chemical-resistant gloves.
- Keep out of reach of children and pets.

Air

Hang garments outdoors to air.

Pre-rinse

Use one of three methods:

1. Hose off garments outdoors.
2. Rinse in separate tub or pail.
3. Rinse in automatic washer at full water level.

Pretreat (heavily soiled garments)

Use heavy-duty liquid detergent.

Washer Load

Wash garments separate from family wash.

Wash garments contaminated with the same pesticide together.

Never use the “sudsaver” feature on your machine when laundering pesticide-soiled clothes.

Load Size

Wash only a few garments at once.

Water Level

Use full water level.

Water Temperature

Use **hot** water, as hot as possible.

Wash Cycle

Use **regular** wash cycle, at least 12-minutes.

Laundry Detergent

Use a **heavy-duty** detergent.

Use amount recommended on package or more for heavy soil or hard water.

Remember to use high-efficiency (HE) detergents in HE and front-loading washers.

Rinse

Use a **full** warm rinse.

Rewash

Rewash contaminated garments **two or three times** before reuse for more complete pesticide removal.

Dry

Line drying is preferable to avoid contaminating dryer.

Clean Washer

Run complete, but empty, cycle.
Use **hot water and detergent.**

Prepared by Charlotte Coffman, College of Human Ecology, Department of Fiber Science and Apparel Design, Cornell University

PESTICIDE EMERGENCY NUMBERS

Emergency responder information on pesticide spills and accidents…

CHEMTREC 800-424-9300

For pesticide information…

National Pesticide Information Center 800-858-7378

To Report Oil and Hazardous Material Spills in New York State…

NYS Spill Hotline 800-457-7362

Poison Control Centers

Poison Control Centers nationwide 800-222-1222

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