



2022

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.

2022 Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production

Authors

Stephen Reiners (Horticulture – Geneva; *Editor; cultivar selection and fertility*)
Elizabeth Bihn (Food Science – Geneva; *produce safety*)
Paul D. Curtis (Natural Resources – Ithaca; *wildlife management*)
Michael Helms (Cornell Cooperative Extension Pesticide Safety Education Program (CCE-PSEP) – Ithaca; *pesticide information*)
Margaret T. McGrath (Plant Pathology – Long Island Horticultural Research and Extension Center, Riverhead; *disease management*)
Brian A. Nault (Entomology – Geneva; *insect pest management*)
Abby Seaman (NYS IPM Program – Geneva; *integrated pest management*)
Lynn Sosnoskie (Horticulture – Geneva; *weed management*)

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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	
EQ 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

Δ Rate or other application restrictions apply. See label for more information.

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 (December 2021). Changes in pesticide registrations, regulations, and guidelines occurring after publication are available in county Cornell Cooperative Extension offices or from the Cornell Cooperative Extension Pesticide Safety Education Program (CCE-PSEP) (psep.cce.cornell.edu).

Trade names used herein are for convenience only. No endorsement of products is 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: Pepper field, Ransomville, Niagara County. (Photo by: Elizabeth Buck, Cornell Vegetable Program.)

Chapter 1 – Integrated Crop and Pest Management	1	Chapter 9 – Transplant Production.....	71
1.1 Background	1	9.1 Cultural Practices	71
1.2 Practicing IPM.....	1	9.2 Growing Media	71
1.3 IPM Components.....	1	9.3 Plant Containers	72
1.4 IPM Tactics	2	9.4 Transplanting.....	72
Chapter 2 – Disease Management.....	3	9.5 Planting Dates	72
2.1 General Principles	3	9.6 Disease Management.....	72
2.2 Diagnosis of Disease	3	Chapter 10 – Postharvest Handling	74
2.3 Disease Management Tactics	3	10.1 Background	74
Chapter 3 – Insect Management	18	10.2 Harvest Considerations.....	74
3.1 General Principles	18	10.3 Clean Surfaces and Containers	74
3.2 Management Options	18	10.4 Washing and Chlorination.....	74
3.3 Managing Resistance.....	20	10.5 Cooling.....	75
Chapter 4 – Weed Management.....	23	10.6 Chilling Injury	75
4.1 General Principles	23	Chapter 11 – Organic Vegetable Production	76
4.2 Management Options	24	11.1 Organic Certification.....	76
4.3 Managing Herbicide Resistance and Persistence.....	27	11.2 Organic Farm Plan	76
Chapter 5 – Wildlife Damage Management.....	31	11.3 Soil Health.....	76
5.1 Deer.....	31	11.4 Cover Crops	76
5.2 Woodchucks.....	31	11.5 Field Selection.....	78
5.3 Rabbits	32	11.6 Weed Management.....	79
5.4 Raccoons	32	11.7 Crop & Soil Nutrient Management	80
5.5 Birds.....	33	11.8 Using Organic Pesticides.....	84
Chapter 6 – Pesticide Information and Use	35	Chapter 12 – Asparagus.....	86
6.1 Pesticide Classification and Certification.....	35	12.1 Recommended Varieties.....	86
6.2 Use Pesticides Safely.....	35	12.2 Planting Methods.....	86
6.3 Pollinator Protection.....	36	12.3 Fertility.....	86
6.4 New York State Pesticide Use Restrictions.....	37	12.4 Harvesting	86
6.5 Verifying Pesticide Registration and Restricted-Use		12.5 Disease Management.....	87
Status.....	37	12.6 Insect Management.....	88
6.6 Check Label for Site and Pest	37	12.7 Weed Management.....	89
6.7 Pesticide Recordkeeping/Reporting	37	12.8 References	94
6.8 EPA Worker Protection Standard (WPS) for		Chapter 13 – Beans – Dry, Snap, and Lima	95
Agricultural Pesticides	38	13.1 Varieties	95
6.9 Reduced-risk Pesticides, Minimum-risk Pesticides, and		13.2 Planting Methods.....	95
Biopesticides	38	13.3 Fertility.....	95
6.10 FIFRA 2(ee) Recommendations.....	39	13.4 Harvesting	95
6.11 Protecting Our Environment.....	39	13.5 Disease Management.....	96
6.12 Proper Pesticide Use.....	40	13.6 Insect Management.....	106
6.13 Spray Equipment Distance Learning	53	13.7 Weed Management.....	116
6.14 Storage.....	53	13.8 References	122
6.15 References	54	Chapter 14 – Beets.....	123
Chapter 7 – General Culture.....	55	14.1 Varieties	123
7.1 Mulches.....	55	14.2 Planting Methods.....	123
7.2 Season Extension.....	56	14.3 Fertility.....	123
7.3 Rye Strip Windbreaks	57	14.4 Harvesting	123
7.4 Raised Bed Systems	57	14.5 Disease Management.....	124
7.5 Irrigation.....	58	14.6 Insect Management.....	127
7.6 Food Safety	60	14.7 Weed Management.....	129
Chapter 8 – Soil Management.....	61	14.8 References	132
8.1 Soils and Fertility	61	Chapter 15 – Cabbage, Broccoli, Cauliflower, Brussels	
8.2 Field and Soil Evaluation	61	Sprouts	133
8.3 Crop Rotation.....	61	15.1 Varieties	133
8.4 Cover Crops	61	15.2 Planting Methods.....	133
8.5 Reduced Tillage.....	63	15.3 Fertility.....	133
8.6 Manure	64	15.4 Harvesting	134
8.7 Sewage Sludges.....	65	15.5 Disease Management.....	135
8.8 Soil Testing	65	15.6 Insect Management.....	145
8.9 Soil pH	66	15.7 Weed Management.....	161
8.10 Fertilizers.....	67	15.8 References	165

Chapter 16 – Carrots	166
16.1 Varieties	166
16.2 Planting Methods.....	166
16.3 Fertility	166
16.4 Harvesting	166
16.5 Disease Management.....	167
16.6 Insect Management.....	173
16.7 Weed Management.....	177
16.8 References	181
Chapter 17 – Cucurbits – Cucumber, Melon, Pumpkin, Squash, and Watermelon.....	182
17.1 Varieties	182
17.2 Planting Methods.....	182
17.3 Fertility	182
17.4 Harvesting	182
17.5 Disease Management.....	184
17.6 Insect Management.....	211
17.7 Weed Management.....	221
17.8 References	226
Chapter 18 – Eggplant	227
18.1 Varieties	227
18.2 Planting Methods.....	227
18.3 Fertility	227
18.4 Harvesting	227
18.5 Disease Management.....	228
18.6 Insect Management.....	231
18.7 Weed Management.....	236
18.8 References	238
Chapter 19 – Lettuce and Endive.....	239
19.1 Varieties	239
19.2 Planting Methods.....	239
19.3 Fertility	239
19.4 Harvesting	239
19.5 Disease Management.....	240
19.6 Insect Management.....	249
19.7 Weed Management.....	256
19.8 References	258
Chapter 20 – Onions	259
20.1 Varieties	259
20.2 Planting Methods.....	259
20.3 Fertility	259
20.4 Harvesting	259
20.5 Disease Management.....	260
20.6 Insect Management.....	274
20.7 Weed Management.....	281
20.8 References	285
Chapter 21 – Peas.....	287
21.1 Varieties	287
21.2 Planting Methods.....	287
21.3 Fertility	287
21.4 Harvesting	287
21.5 Disease Management.....	288
21.6 Insect Management.....	290
21.7 Weed Management.....	290
21.8 References	296
Chapter 22 – Peppers.....	297
22.1 Varieties	297
22.2 Planting Methods.....	297
22.3 Fertility	297
22.4 Harvesting	298
22.5 Disease Management.....	298

Chapter 22 – Peppers (continued)	
22.6 Insect Management.....	305
22.7 Weed Management.....	310
22.8 References	314
Chapter 23 – Potatoes	315
23.1 Recommended Varieties.....	315
23.2 Planting Methods.....	315
23.3 Fertility	316
23.4 Harvesting	316
23.5 Disease Management.....	319
23.6 Insect Management.....	341
23.7 Weed Management.....	357
23.8 References	361
Chapter 24 – Spinach.....	362
24.1 Varieties	362
24.2 Planting Methods.....	362
24.3 Fertility	362
24.4 Harvesting	362
24.5 Disease Management.....	362
24.6 Insect Management.....	368
24.7 Weed Management.....	371
24.8 References	374
Chapter 25 – Sweet Corn.....	375
25.1 Recommended Varieties.....	375
25.2 Planting Methods.....	375
25.3 Fertility	375
25.4 Harvesting	376
25.5 Disease Management.....	376
25.6 Insect Management.....	383
25.7 Weed Management.....	397
25.8 References	404
Chapter 26 – Tomatoes - Field	406
26.1 Varieties	406
26.2 Planting Methods.....	406
26.3 Fertility	406
26.4 Harvesting	407
26.5 Disease Management.....	407
26.6 Insect Management.....	427
26.7 Weed Management.....	438
26.8 References	441
Chapter 27 – Turnips and Radishes	442
27.1 Recommended Varieties.....	442
27.2 Planting Methods.....	442
27.3 Fertility	442
27.4 Harvesting	442
27.5 Disease Management.....	442
27.6 Insect Management.....	442
27.7 Weed Management.....	445
27.8 References	446
Appendix.....	447

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 (nysipm.cornell.edu) and Northeastern IPM Center (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 chemical controls when they are needed. Taking advantage of some of the simple and relatively inexpensive pesticide

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. Additional 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.

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.

Fungicide (active ingredient)	Crop																		
	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
Cymbal Balance (cymoxanil + propamocarb hydrochloride)	27 + 28											X		X	X				
Decree (fenhexamid), Gr. Hs., Tsp.	17											X	X	X				X	
Dividend Extreme (difenoconazole + mefenoxam)	3 + 4																		X
*Elatus (azoxystrobin + benzovindiflupyr)	11 + 7																	X ¹⁴	X ⁷
Elixir (mancozeb + chlorothalonil)	M03 + M05																	X	
Emesto Silver (prothioconazole + penflufen)	3 + 4																	X	
Endura (boscalid)	7		X ²¹	X ⁷		X	X	X	X	X	X	X	X	X ¹⁴	X	X ⁷	X ⁷	X	X ¹⁰
Firewall (streptomycin sulfate)	25																	X	
Flint Extra (trifloxystrobin)	11	X ¹⁸⁰			X ⁷					X ⁷		X	X ³		X			X ³	X
Forum (dimethomorph)	40					X ⁷	X ⁷	X ⁷	X ⁷		X ⁷	X	X	X	X	X		X	X ⁴
Gatten (flutianil)	U13											X			X				X
Gaucho-MZ (imidacloprid + mancozeb), seed piece	Ins + M03																		X
*Gavel 75DF (zoxamide + mancozeb)	22 + M03											X ⁵			X ⁵				X ³
Gem 500SC (trifloxystrobin)	11				X ⁷					X ⁷									X ⁷
Headline AMP (pyraclostrobin + metconazole)	11 + 3																		X ⁷
Headline SC (pyraclostrobin), in-furrow ⁰ , foliar varies	11		X ²¹	X ⁷													X ⁷		X ³
Inspire Super (difenoconazole + cyprodinil)	3 + 9					X ⁷	X ⁷	X ⁷	X ⁷		X ⁷	X ⁷			X ⁷	X ⁷	X ¹⁴		X ⁷
																			X ⁷
																			X
																			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.*

Insecticide (Active Ingredient)	Mode of Action ¹	Crop																	
		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
*ΔProclaim (<i>emamectin benzoate</i>)	6					X	X	X	X		X								
*Provado (<i>imidacloprid</i>)	4			X		X	X	X	X		X		X					X	X
Radiant SC (<i>spinetoram</i>)	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sevin XLR (<i>carbaryl</i>)	1A	X	X	X		X	X	X	X	X	X	X	X					X	X
*Vendex 50W (<i>fenbutin-oxide</i>)	12												X						
*†ΔVoliam Xpress (<i>chlorantraniliprole + lambda-cyhalothrin</i>)	3, 28		X	X		X	X	X	X		X	X		X				X	X
*Warrior II with Zeon Technology (<i>lambda-cyhalothrin</i>)	3		X	X		X	X	X	X		X	X			X			X	X
Xentari (<i>Bt var. aizawai</i>)	11					X	X	X	X		X								

* Restricted-use pesticide

† = Not for use in Nassau/Suffolk Counties

Δ = Rate or other application restrictions apply.

¹ Modes of Action² Except cucumber

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 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 that remain in-crop at the end of the season can significantly impede harvest operations. 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. 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. Some online resources for weed identification are compiled at the New York State IPM website: nysipm.cornell.edu/agriculture/vegetables/weed-identification/. Common problem weeds in New York State are highlighted below.

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. 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.

Quackgrass. Quackgrass is a common, cool-season, perennial grass that spreads by both rhizomes and seeds. The species can be identified by leaves that are rolled in the bud, a short membranous ligule and clasping auricles at the collar region. Quackgrass is most effectively managed by a combination of chemicals and tillage, although care must be taken to avoid spreading quackgrass rhizomes into clean fields via farm equipment. Check specific crop recommendations for more targeted control options.

Nutsedge (nutgrass). Nutsedge is a perennial weed with three-angled stems and long, grass-like leaves. The species spreads by both rhizomes and tubers. Dormant tubers can remain viable in the soil for years, making the species difficult to eliminate. Nutsedge does not emerge until the soil is warm; in most fields, weeds such as lambsquarters, mustard, ragweed, and quackgrass emerge two or three weeks earlier. Nutsedge grows vegetatively until midsummer when it begins to form daughter tubers as daylengths start to decrease in July. Tuber formation is greatly accelerated in August and September, when daylengths become even shorter. In the fall, even small plants can form tubers.

Both cultural practices and herbicides are needed to manage nutsedge infestations. The species is sensitive to dense shade and successful control programs need to capitalize on this characteristic. For example, when planted early and at a close spacing, most pumpkins and squash can provide the shade needed to suppress nutsedge growth. Cultivation can be used between rows to manage nutsedge until the crop canopy closes. Plant and harvest early on fields for which selective chemicals are not available. Fall tillage and nonselective chemicals can then be used. When selective chemicals are available (dry and snap beans, potatoes, and sweet corn), delay planting and treatment until tubers have sprouted. Herbicides do not damage dormant tubers. See specific crop information for recommendations.

Perennial broadleaf weeds. Perennial broadleaf weeds such as field and hedge bindweed, Canada thistle, horse-

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

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) created two classifications of pesticides – general-use and restricted-use. **General-use pesticides** may be purchased and used by anyone. **Restricted-use pesticides can** only be purchased by a certified applicator. Restricted-use pesticides must also be used by a certified applicator or someone under their supervision.

The same federal law that classifies pesticides divided applicators into two groups: private and commercial. **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. A farmer must be certified as a private applicator in order to purchase and use restricted-use pesticides on agricultural commodities. (No certification is needed if a farmer does not use restricted-use pesticides.)

A **commercial applicator** uses or supervises the use of pesticides for any purpose or on any property not covered by the private applicator classification. In New York, a commercial applicator must be certified to purchase or use any pesticide whether it is general- or restricted-use.

Information about pesticide certification and classification is available from your Cornell Cooperative Extension office (cce.cornell.edu/localoffices), regional NYSDEC pesticide specialist (www.dec.ny.gov/about/558.html), the Pesticide Applicator Training Manuals (<https://www.cornellstore.com/books/cornell-cooperative-ext-pmep-manuals>), or the Cornell Cooperative Extension Pesticide Safety Education Program (psep.cce.cornell.edu).

6.2 Use Pesticides Safely

Using pesticides imparts a great responsibility on the user to protect their health and that of others and to protect the environment. Keep in mind there is more to “pesticide use” than the application. Pesticide use 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 are also regulated by state and federal laws and regulations intended to protect the user, the community, and the environment from any adverse effects pesticides may cause.

6.2.1 Plan Ahead

Many safety precautions should be taken *before* you actually begin using pesticides. Too many pesticide applicators are dangerously and needlessly exposed to pesticides while they are preparing to apply them. 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 directions and precautions on the label. 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

Carelessness in transporting pesticides can result in broken containers, spills, and contamination of people and the environment. Once pesticides are in your possession, you are responsible for safely transporting them. Accidents can occur even when transporting materials 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 needs depend on the pesticide being handled. **Required personal protective equipment (PPE) are listed on pesticide labels.** The required PPE are based on the pesticide’s toxicity, route(s) of exposure, and formulation. Label required PPE are the minimum that must be worn during the pesticide’s use. Pesticide users can always wear more protection than required.

The type of protective equipment used depends on the type and duration of the activity, where pesticides are being used, and exposure of the handler. Mixing/loading procedures often require extra precautions. Studies show you are at a greater risk of accidental poisoning when handling pesticide concentrates. Pouring pesticide concentrates from one container to another is the most hazardous activity.

Engineering controls are devices that help prevent accidents and reduce a pesticide user’s exposure. One example is a closed mixing/loading system that reduces the risk of exposure when dispensing concentrated pesticides. 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 crops, and harm the environment. Choose weather conditions, pesticides, application equipment, pressure, droplet size, formulations, and adjuvants that minimize drift and runoff hazards. See product labels for specific application and equipment requirements.

applied over a known area. Liquid chemical application requires information on the volume (gallons) of material applied.

The equipment required to calibrate a broadcast sprayer using this technique includes a tape measure, a stopwatch, and a measuring jar graduated in ounces. Personal safety protection equipment should also be worn when working around the sprayer.

The most accurate calibrations are performed by measuring the output of each nozzle (gallons per minute, gpm), measuring nozzle pressure (pounds per square inch, psi) with a pressure gauge on the spray boom, and measuring travel speed (miles per hour, mph) in the field with the sprayer operating.

6.12.4 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 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.

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

Your figures:

Tractor gear _____ Engine revs. _____

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

6.12.5 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	_____	20
--------	-------	----

GPA(from manufacturer's label)

Measured sprayer speed	_____	4 MPH
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Nozzle spacing	_____	20 inches
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Step 3. Calculate the required nozzle output

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

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

$$\text{Your figures: GPM} = \frac{\text{ } \times \text{ } \times \text{ }}{5940} = \frac{\text{ }}{5940} = \text{ } \text{ GPM}$$

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

6.12.6 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:

$$\text{Nozzle spacing} = \text{sprayed band width or swath width (in inches)}$$

For multiple nozzle directed applications:

$$\text{Nozzle spacing} = \text{row spacing (in inches) divided by the number of nozzles per row.}$$

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

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

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

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 $K \times 10^5$ 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 10.2.1). 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
<u>Sodium Hypochlorite, 5.25%</u>			
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
<u>Sodium Hypochlorite, 12.75%</u>			
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

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 can be downloaded from New York State Department of Ag 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>). The National Sustainable Agriculture Information Service, (formerly ATTRA), has produced a guide to organic certification that includes a template for developing an organic farm plan (<https://attra.ncat.org/product/organic-system-plan-template-for-crop-and-or-livestock-production/>).

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.

Chapter 12 – Asparagus

12.1 Recommended Varieties

Many newer varieties are all-male hybrids, whereas traditional varieties such as Mary Washington are dioecious with 50 percent male and 50 percent female plants. The new male hybrids are higher yielding, more vigorous, and do not produce seeds.

Table 12.1.1 Recommended asparagus varieties

Jersey Supreme (RR, FT) ¹	Jersey Giant (RR,FT)
Jersey Knight (RR,FT)	

¹ RR = Rust resistant; FT = Fusarium tolerant

12.2 Planting Methods

Crowns. One-year-old crowns are generally planted. Commercially, crowns are dug in the fall after one season's growth, stored, and sold in the spring. If a grower establishes his/her own nursery, crowns may be left in the field over the winter, dug in the spring, and replanted immediately. Crowns are placed in the bottoms of furrows six to eight inches deep with buds up and covered with 1½ inches of soil. Furrows are gradually filled in over the first growing season, by moving soil toward the plants during cultivation until the field is again level.

Transplants. Asparagus fields can be established using ten- to 12-week-old transplants. Transplants are planted in furrows six to eight inches deep. The furrow should be wide and contain a three-inch flattened mound at the bottom in a modified W-shape. Placing the transplant on the mound protects the plant from being washed out or covered by soil during a heavy rain. Furrows are not completely filled in at planting. Instead, the root mass of the transplant is covered, and the soil is gradually moved into the furrows with cultivation over the first growing season.

Table 12.2.1 Recommended spacing.

Row (in feet)	In-row (in inches)
4.5-6 ¹	10-18 ²

¹ Use spacing that allows room for farm equipment. Mature ferns can become large and difficult to cover with sprays if planted too closely.

² Early yields from closely spaced plants will be high, but as roots spread, the closely spaced plants become crowded and spear diameter decreases.

12.3 Fertility

Apply adequate lime to bring the pH to between 6.0 and 6.5. If a large amount of lime is needed, apply half before plowing and incorporate the remainder after plowing. Remember, asparagus will be in the field for eight to 12 years, so proper soil preparation prior to planting is essential. See Table 12.3.1 for the recommended rates of nitrogen, phosphorus, and potassium.

12.4 Harvesting

Do not harvest asparagus the year of planting. Asparagus can be harvested the second year after planting. A traditional harvest sequence calls for cutting two weeks the first year of harvest, four weeks the second, and six to eight weeks thereafter. These are general guidelines, and the length of the harvest period should be adjusted according to the spear size. When spears are predominantly small in diameter, harvest should be stopped. Fresh-market asparagus is cut or snapped by hand when the spears are about ten inches tall. In warm weather, fields should be harvested daily. Damaged or thin shoots should be cut and discarded. After harvesting, spears should be washed, cooled, trimmed to a uniform length, and graded by diameter. Spears can be stored for up to three weeks at 36°F and 95 percent relative humidity.

Table 12.3.1 Recommended nutrients based on soil tests.

N pounds/acre	P ₂ O ₅ pounds/acre			K ₂ O pounds/acre			Comments
	Soil Phosphorus Level			Soil Potassium Level			
	<i>low</i>	<i>med.</i>	<i>high</i>	<i>low</i>	<i>med.</i>	<i>high</i>	
New plantings							
50	110	60	30	150	100	50	Total recommended
0	110	60	30	150	100	50	Broadcast and disk-in.
50	0	0	0	0	0	0	Sidedress at first cultivation.
Cutting beds							
50	75	50	25	80	60	40	Total recommended
50	75	50	25	80	60	40	Apply in the spring before spear emergence. Incorporate lightly

13.5.1 Anthracnose (*Colletotrichum lindemuthianum* and other species)

(Primarily a problem on dry beans. Has become less common at least partly due to improved seed treatments)

Time for concern: From seeding stage through the end of harvest

Key characteristics: Seedlings have dark brown to black, sunken lesions on cotyledons and stems. Under moist conditions, small, pink masses are produced in the lesions. On the pods, small, reddish brown to black blemishes and distinct, circular, reddish brown lesions are typical symptoms. A prolonged wet period is necessary for the fungus to establish infection. The fungus is seed- or soilborne. Anthracnose fact sheet.

Management Option	Guideline
Scouting/thresholds	Dry bean fields should be scouted at least twice between midseason and harvest. Record the occurrence and severity of anthracnose. No thresholds have been established. Fungicides have not been effective in research trials conducted under ideal conditions for disease development.
Resistant varieties	Several races of the fungus exist. Some varieties are resistant to one or more races. The most common race in New York has been the beta race. Consult local extension educators to learn what varieties have shown resistance to this race.
Crop rotation	Minimum two to three year rotation.
Site selection	Select fields with good air movement and water drainage.
Seed selection/treatment	Plant only western-grown, certified seed.
Postharvest	Crop debris should be destroyed as soon as possible to remove this source of disease for other plantings and to initiate decomposition of diseased material.
Sanitation	Since the fungus is efficiently disseminated in water, fields should not be entered for cultivation or pesticide applications when plants are wet.

Compound(s) Anthracnose

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
*†Approach (<i>picoxystrobin</i>) (Group 11)	6-12 fl oz/acre	14	12	1.2 - 2.4	Dry beans only. No more than 2 applications per year.
*Aprovia Top (<i>difenoconazole</i> + <i>benzovindiflupyr</i>) (Group 3 + 7)	10.5-11 fl oz/acre	14	12	3.1 - 3.2	Dry beans only. Aerial application is prohibited in NYS. No more than 2 max applications.
Bravo Weather Stik (<i>chlorothalonil</i>) or OLP (Group M 05)	1.38-2 pts/acre	14 dry, 7 snap	12	29.1 - 42.2	Dry beans only.
Headline SC (<i>pyraclostrobin</i>) (Group 11) No aerial application within 100 ft. of aquatic habitats in NYS. Max 2 consecutive applications and 18 fl oz/A/year.	6-9 fl oz/acre	7 snap, lima 21 dry	12	2.5 - 3.7	See comment below
Inspire Super (<i>difenoconazole</i> + <i>cyprodinil</i>) (Group 3 + 9)	16-20 fl oz/acre	14	12	10.3 - 12.9	Dry beans only.
*Miravis Neo (<i>azoxystrobin</i> + <i>propiconazole</i> + <i>pydiflumetofen</i>) (Group 11 + 3 + 7)	13.7 fl oz/acre	14	12	5.5	Dry beans only.
*Miravis Top (<i>difenoconazole</i> + <i>pydiflumetofen</i>) (Group 3 + 7)	13.7 fl oz/acre	14	12	4.2	Dry beans only.
*†Priaxor (<i>pyraclostrobin</i> + <i>fluxapyroxad</i>) (Group 11 + 7) No aerial application within 100 ft. of aquatic habitats in NYS. No more than 2 consecutive, 2 max applications.	4-8 fl oz/acre	7 snap, lima 21 dry	12	2.8 - 5.6	See comment below

18.6.2 Colorado potato beetle (CPB) (*continued*)

Management Option	Guideline
Resistance management	Given the phenomenal ability of the CPB to develop resistance to insecticides, a major goal in managing this pest is to delay the onset of resistance. One way to achieve this is to rotate insecticide applications among different insecticide classes. Insecticides are broken down into classes in Table 3.1 in the Insect Management Chapter. For more information about CPBs, see Section 23.6 in the Potato chapter.
Natural enemies	Numerous organisms exist in the field. Both parasitoids and predators are useful. Use Reference 1 or https://biocontrol.entomology.cornell.edu/index.php for identification of natural enemies.
Resistant varieties	No resistant varieties are available.
Crop rotation	One year rotation to small grains or corn can result in greater than 90 percent reduction of early-season, adult infestation.
Site selection	Eggplant fields should be a considerable distance from overwintering sites.
Seed selection/treatment, Postharvest, and Sanitation	These are not currently viable management options.

Compound(s) Colorado potato beetle

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
*†Actara (<i>thiamethoxam</i>) (Group 4A)	2.0-3.0 oz/acre	0	12	1 - 1.6	Foliar application only.
*Admire Pro Systemic Protectant (<i>imidacloprid</i>) (Group 4A)	7.0-10.5 fl oz/acre	21 for soil apps, 0 for foliar	12	7.1 - 10.7	Soil application only.
*Admire Pro Systemic Protectant (<i>imidacloprid</i>) (Group 4A)	1.3-2.2 fl oz/acre	21 for soil apps, 0 for foliar	12	1.3 - 2.2	Foliar application only.
*Agri-Mek SC (<i>abamectin</i>) (Group 6)	1.75-3.5 fl oz/acre	7	12	0.3 - 0.6	
Assail 30SG (<i>acetamiprid</i>) (Group 4A)	1.5-2.5 oz/acre	7	12	0.8 - 1.3	
*Baythroid XL (<i>beta-cyfluthrin</i>) (Group 3A)	1.6-2.8 fl oz/acre	7	12	0.4 - 0.7	
*†ΔCoragen (<i>chlorantraniliprole</i>) (Group 28)	3.5-5 fl oz/acre	1	4	0.8 - 1.1	In NYS, do not apply by air and do not apply within 100 ft of a water body.
*†ΔEndigo ZC (<i>thiamethoxam</i> + <i>lambda-cyhalothrin</i>) (Group 4A + 3A)	4.0-4.5 fl oz/acre	5	24	2.2 - 2.5	
§Entrust SC (<i>spinosad</i>) (Group 5)	3-6 fl oz/acre	1	4	0.6 - 1.3	No more than 6 max applications.
*†Exirel (Dupont) (<i>cyantraniliprole</i>) (Group 28)	7-13.5 fl oz/acre	1	12	Not Available	
*ΔGladiator EC (<i>zeta-cypermethrin</i> + <i>avermectin B1</i>) (Group 3A + 6)	19 fl oz/acre	7	12	0.4	No aerial application in NYS.
*Hero (<i>bifenthrin</i> + <i>zeta-cypermethrin</i>) (Group 3A + 3A)	4.0-10.3 fl oz/acre	7	12	1.3 - 3.3	

19.7 Weed Management

Key characteristics: Weed fact sheets provide a good color reference for common weed identification. See Cornell Weed Identification web site. See Chapter 4 for information on scouting/thresholds, site selection, cultivation, and banding of herbicides.

<i>Management Option</i>	<i>Guideline</i>
Scouting/thresholds	Weeds may be unevenly distributed over a field. Localized areas of severe weed infestations or atypical conditions, such as poorly drained areas, high spots, and field edges, may be recorded on a weed map. A weed map should be on file for each field. Make a rough sketch of the field, including landmarks, boundaries, crop row direction, compass directions, roads, planting date, map preparation date, and any other important details. The following information should be indicated on the map: species of weed, size of weed, density of each species, and distribution of weed. Scout fields two to three weeks after planting to evaluate the success of the current season's program and at or near harvest to help predict weed control practices that will be necessary for the following year.
Site selection	Refer to weed maps to avoid problem weeds when choosing fields for lettuce and endive.
Cultivation	Cultivation is necessary in lettuce and endive weed control. See NYS IPM Weed IPM web pages and SARE "Steel in the Field: A Farmer's Guide to Weed Management." (www.sare.org/publications/steel/steel.pdf)
Banding herbicides	Banding of herbicides at planting is not useful in lettuce and endive production.

Compound(s) all (non-selective)

TIMING KEY: PPI = pre-plant incorporated; PreE = pre-emergent; PostE = post-emergence

<i>Timing</i>			<i>Product Name (active ingredient, weight of active per unit of herbicide, group number)</i>
PPI	PreE	PostE	<i>Notes</i>
	X		Roundup WeatherMAX (glyphosate, 5.5 lb/gal, group 9) <i>Rate:</i> 1-1.4 pts/acre weeds < 6" tall, 1.4-2 pt/ac weeds > 6" tall <i>AI per acre:</i> 0.69-0.96 lbs/acre weeds < 6" tall, 0.96-1.4 weeds > 6" tall <i>PHI:</i> 14 <i>REI:</i> 4 <i>Field Use EIQ:</i> 7.8 - 10.9 <i>Comments:</i> May be applied after seeding but before crop emergence. For use on mineral and muck soils.

Compound(s) annual and perennial grasses

TIMING KEY: PPI = pre-plant incorporated; PreE = pre-emergent; PostE = post-emergence

<i>Timing</i>			<i>Product Name (active ingredient, weight of active per unit of herbicide, group number)</i>
PPI	PreE	PostE	<i>Notes</i>
		X	*ΔSelect Max (clethodim, 0.97 lb/gal, group 1) <i>Rate:</i> 9-16 fl oz/acre <i>AI per acre:</i> 0.068-0.12 lbs/acre <i>PHI:</i> 14 <i>REI:</i> 24 <i>Field Use EIQ:</i> 1.3 - 2.2 <i>Comments:</i> For control of numerous annual and perennial grasses that are not stressed. DO NOT apply more than 0.485 lb ai per acre per season. Application on LONG ISLAND is restricted to no more than 0.25 lb ai per acre per season. Always use only 0.25% v/v non-ionic surfactant (NIS) with *†Select Max. Other clethodim products may be registered; read labels carefully. Tank mixes with or within 2-3 days of other pesticides may reduce grass control and increase crop injury potential. Higher rates or repeat applications may be necessary for perennial grass control.

* Restricted-use pesticide.

Δ Rate and/or other application restrictions apply. See label for more information.

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	nicosulfuron	75 DF	352-560
Aim EC	carfentrazone	2.0 EC	279-3241
Assure II	quizalofop p-ethyl	0.88 EC	352-541
*Atrazine 90WDG	atrazine	90 WDG	34704-622
*Atrazine 4L	atrazine	4 L	34704-69
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
Broadloom	bentazon	4 L	70506-306
Callisto	mesotrione	4SC	100-1131
Caparol	prometryn	4 L	100-620 (SLN NY-140007)
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	acetochlor	7 EC	524-473
Impact	topramezone	2.8 L	5481-524
Karmex DF	diuron	80 DF	66222-51
*Kerb 50-W	pronamide	50 WP	62719-397
Laudis	tembotrione	3.5 EC	264-860
Lorox DF	linuron	50 DF	61842-23
Matrix	rimsulfuron	25 DF	352-556
Metribuin 4L	metribuzin	4L	42750-361
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
*†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