2020 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.

2020 Cornell Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production

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Abbreviations and Symbols Used in This Publication

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

* .... 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 (November 2019). Changes in pesticide registrations, regulations, and guidelines occurring after publication are available in county Cornell Cooperative Extension offices or from the Pesticide Management Education Program web site (pmep.cce.cornell.edu).

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

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: A field of staked tomatoes in Columbia County. (*Photo by: Annie Mills, Cornell Cooperative Extension, Wayne County.)*

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.

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. Consult the listed references for details on scouting and trapping of pests.

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 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

Chapter 2 – Disease Management

2.1 General Principles

For a vegetable to become truly diseased, several conditions must be present: a susceptible host plant, a pathogenic organism, a good method of distributing the organism, and the proper environment for it to exist, enter the plant, and thrive. When these conditions are met, infection occurs, and a disease agent becomes established. The choice of a proper management tactic 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 agent distribution; past, present, and future environmental conditions; and certain economic considerations. Effective management techniques include: use of resistant varieties; use of non-infested soil or long rotations; sterilization of soil with steam or chemicals; use of clean seed, either certified or grown in disease-free areas; treatment of seed with heat or chemicals; control of insects and weed hosts; monitoring of weather conditions; use of biological control agents; and proper timing and application of fungicides or nematicides.

Effective management of vegetable diseases requires preventing disease or, if this is not feasible, slowing the spread of disease once it occurs. What can be done to prevent disease outbreaks or reduce the risk of early-season epidemics? Nine procedures and the current estimated percentage of importance of each toward vegetable disease control have been recommended for many years: rotating crops (30%), spraying when necessary (20%), treating the seed (15%), using clean seed (10%), planting resistant varieties (5%), controlling weeds (5%), aerating the soil properly (5%), draining and fertilizing the soil (5%), and practicing good sanitation (5%). It is unlikely that all diseases of a particular crop can be controlled by simply following these procedures. Nevertheless, the extent of disease and the concomitant costs of controlling them can be significantly reduced by following as many of these procedures as possible. Growers should note that this estimate indicates that spraying is only responsible for 20 percent of disease control. Using the other disease control techniques, which contribute 80 percent of disease control cannot only greatly improve disease control, but also lessen the costs of spray materials and result in better quality crops.

2.2 Diagnosis of Disease

The first step in disease management should be accurate diagnosis. It is important to differentiate between infectious diseases (e.g. those caused by fungi, bacteria, phytoplasma, viruses, viroids, and nematodes that can spread from plant to plant) and noninfectious diseases or disorders (e.g., damage caused by mites and insects, physiological disorders, air pollutants, nutrient imbalances, water imbalances and herbicide 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 fields to different crops each year cannot be overemphasized as one of the most important and easily implemented disease control strategies. This practice avoids the buildup of certain plant pathogens in the soil. The longer the rotation, the less likely that an early-season disease outbreak will occur. Because pathogens usually attack members of the same plant family, it’s best to avoid planting successive crops belonging to the same family. Choices of unrelated crops to be rotated include beans to sweet corn, leafy vegetables to cucurbits, cucurbits to crucifers, and crucifers to sweet corn. Rotating beans with a grain crop such as barley, oats, rye, wheat, or field corn or with a forage crop is beneficial for root-rot control. One or two years in a grain crop are often long enough to prevent severe root rot when a field isn’t heavily infested.

Some soilborne diseases are not readily controlled by rotation. Such diseases are caused by pathogens that produce structures that can withstand the effects of time and nonhost crops. Examples 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. Other pathogens are not affected by rotation because they overwinter in southern states, and new inoculum is blown into the area every year. This group includes sweet corn rust and downy mildew of cucurbits.

Many pathogens can overwinter successfully in association with plant debris and are unable to survive once the crop residue decomposes. Destruction of current-season crops can eliminate reservoirs for overlapping plantings. Fall tillage is important because it reduces the amount of inoculum that survives the winter.

Fields with a history of poor stand establishment and root diseases should not switch immediately to no-till or reduced tillage practices. The severity and incidence of root diseases and other pests should be reduced first by employing an appropriate crop rotation, deep tillage and other good soil management practices.

Table 2.3.1 Registered conventional fungicides by crop. (See Table 4 in Appendix for biopesticides.)

X = registered; Superscript numbers = days to harvest (DTH). No number = 0 DTH or intended for seed or soil use at planting, or at peak bloom for Rovral use on beans.

		Crop																								
Fungicide (*active ingredient*)	CLASSIFICATION	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
Forum (*dimethomorph*)	**40**					X^{7}	X^{7}	X^{7}	X^{7}		X^{7}	X	X	X	X	X	X		X	X^{4}	X		X		X^{4}	X
Gaucho-MZ (*imidacloprid + mancozeb*), seed piece	Ins + M3																			X						
*Gavel 75DF (*zoxamide + mancozeb*)	22 + M3											X^{5}			X^{5}					X^{3}	X^{5}		X^{5}		X^{5}	X^{5}
Gem 500SC (*trifloxystrobin*), no aerial	**11**				X^{7}					X^{7}										X^{7}						
Headline AMP (*pyraclostrobin + metconazole*), aerial with limits	**11 + 3**																							X^{7}		
Headline SC (*pyraclostrobin*), in-furrow^{0}, foliar varies, aerial with limits	**11**		X^{21}	X^{7}														X^{7}		X^{3}				X^{7}		
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^{0}	X^{7}
ManKocide (*mancozeb + copper hydroxide*)	M3 + M1											X^{5}			X^{5}	X^{7}				X^{3}			X^{5}		X^{5}	X^{5}
Maxim MZ (*fludioxonil + mancozeb*), seed piece	12 + M3																			X						
Mertect 340F (*thiabendazole*)	**1**									X										X						
*Miravis Neo (azoxystrobin + propiconazole + pydiflumetofen)	11 + 3 +7		X^{14}																							
*†Miravis Prime (*fludioxonil + pydiflumetofen*)	12 + 7											X^{1}		X	X^{1}					X^{14}	X^{1}		X^{1}		X	X^{1}
*Miravis Top (*difenoconazole + pydiflumetofen*)	3 + 7		X^{14}																							
Moncoat MZ (*flutolanil + mancozeb*), seed piece	**7** + M3																			X						
†Moncut 70 DF (*flutolanil*), in-furrow	**7**																			X						
*Omega 500F (*fluazinam*)	29		X^{30}	X^{14}		X^{50}	X^{50}	X^{50}		X^{7}	X^{50}	X^{7}	X^{30}		X^{30}	X^{7}				X^{14}	X^{7}		X^{7}			X^{30}

Table continues on next page.

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 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 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 infested by corn earworm and fall armyworm, which typically arrive mid to late in the season.

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	Pumpkin and S/W Squash	Spinach	Sweet Corn	Tomato, field
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										
*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 Δ = Rate or other application restrictions apply.

[1]Modes of Action

[2]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.

For more details on classifying insecticides based on mode of action see A.M. Shelton, W.T. Wilsey and D.M. Soderlund, 2001, Insecticide Resistance Management. (nysipm.cornell.edu/publications/res_mgmt/files/res_mgmt.pdf).

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-

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]	Crop																							
		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
Reglone (*diquat*)	*22*		X																X						
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
Sandea (*halosulfuron*)	*2*	X	X	X								X	X		X			X		X		X		X	X
*Select (*clethodim*)	*1*	X	X			X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X
*†Sharpen (*saflufenacil*)	*14*																X								
metribuzin (*metribuzin*)	*5*	X								X							X		X					X	
Sonolan (*ethalfluralin*)	*3*		X																						
*Spin-Aid (*phenmedipham*)	*5*					X															X				
*†Stinger (*clopyralid*)	*4*					X	X	X	X		X										X		X		
Strategy (*ethalfluralin + clomazone*)	*3/13*											X			X					X		X			
Treflan (*trifluralin*)	*3*	X	X	X			X	X	X	X	X						X	X	X				X	X	
(*2,4-D*)	*4*	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	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	E	E	P	E	P	G	G	E	P	P	P	P	P	P	P
Curbit	F	-	P	G	P	P	P	P	P	E	E	G	E	P	P
*†Dacthal	F	F	P	F	P	P	P	F	P	G	G	G	G	P	P
*†Dual Magnum	P	F	P	F	F	E	P	G	P	E	E	E	E	P	G
Goal	G	G	F	E	G	F	F	G	P	P	P	P	P	P	P
*Karmex	E	E	E	E	E	G	G	P	F	E	F	F	E	P	P
*Kerb	F	G	F	G	F	P	F	G	P	E	E	E	E	G	P

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 Pesticide Management Education Program (PMEP) at Cornell University (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 you begin to use 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 the label requires.

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.

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.

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

Your figures:

Tractor gear ___________ Engine revs.___________

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

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 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

6.12.6 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:

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 ten percent 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.

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, and weed management. 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 search online: *Cornell Soil Health.*

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 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 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 found on the New York State Department of Agriculture and Markets Organic Farming Information Center: www.agriculture.ny.gov/AP/Organic/. 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 templates for developing an organic farm plan (http://attra.ncat.org/organic.html). The Rodale Institute has also developed resources for transitioning to organic and developing an organic farm plan (http://rodaleinstitute.org/ farm/organic-system-plan/).

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, www.sare.org/publications/soils.htm. 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" (http://palspublishing.cals.cornell.edu/nra_crof.html) 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

Chapter 16 – Carrots

16.1 Varieties

Long, slender Imperator-type varieties are desired for fresh market. Blunt-tipped Nantes varieties are preferred for sliced, processed products, and blocky Chantenay or Danvers types are used for dicing. Varieties that have done well in trials include Bolero, Magnum, Red core Chantenay, Ya Ya and Danvers. Cultivars vary in susceptibility to aster yellows. See Tables of Disease Resistant Varieties: http://vegetablemdonline.ppath.cornell.edu/Tables/TableList.htm.

16.2 Planting Methods

Carrots are a cool-season crop that can tolerate light frosts. Good quality roots (judged by length, shape, and color) develop when soil temperature is between 60° and 70°F. At warmer temperatures, the roots will be shorter, and internally the color will be lighter orange.

Carrots are biennial, normally producing an enlarged root the first growing season and, after a prolonged cold period (below 45°F), a seedstalk (assuming that the roots are not allowed to freeze). When spring conditions are especially cool, bolting or premature seedstalk development can occur during the first growing season. If this happens, the root will be woody and inedible. Because large seedlings are more susceptible to bolting than are smaller seedlings, premature seedstalk development is generally associated with early spring plantings. Varieties differ greatly in their susceptibility to bolting.

The length of carrot roots is determined within the first few weeks after germination because the taproot quickly penetrates deep into the soil. If the young taproot is injured, it will become branched and forked, making the root unmarketable. Excessive soil moisture, insects, diseases, nematodes, and soil compaction can all markedly affect root quality. Wet soil near harvest will cause the roots to become rough and promote root rot diseases.

Obtaining long, straight, smooth roots is difficult. Light-textured soils that contain few stones or well-drained muck soils are preferred. Primary tillage should be fairly deep, but care must be taken not to impair soil structure by working the soil when wet. Use of raised beds, which tend to increase drainage, aeration, and total depth of tilled soil, can improve the length and shape of roots.

Some carrot varieties (Nantes and related types) are especially susceptible to the formation of chlorophyll (green pigment) on the shoulders and within the core area of the root. To reduce this problem, the soil should be hilled over the shoulders of the roots at the last cultivation.

Table 16.2.1 Recommended spacing.

Type	Row (inches)	In-row	Seed (lb/acre)
Imperator or Nantes	18-36	1.5”	2 to 3
Chantenay or Danvers	18-36	1.5”	1 to 2

16.3 Fertility

Maintain a pH of 6.0 to 6.5 on mineral soils; consider liming when the pH falls below 5.2 on muck soils. See Table 16.3.1 for the recommended rates of nitrogen, phosphorus, and potassium.

16.4 Harvesting

Machine harvesters are used for the processing crop and for roots that are marketed in polyethylene bags. Bunching carrots are hand harvested and tied together.

Carrots can be stored for several months at 32°F and 90 to 95 percent relative humidity. If the temperature is allowed to rise, sprouting will occur. If the relative humidity is too low, the roots will desiccate.

Table 16.3.1 Recommended nutrients based on soil tests.

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	
80-90	***120***	***80***	***40***	***160***	***120***	***60***	***Total recommended***
30-40	80	40	0	120	80	20	Broadcast and disk-in.
20	40	40	40	40	40	40	Deep drill or band place with planter
30	0	0	0	0	0	0	Sidedress 4-6 weeks after seeding Sidedress twice in years with heavy rainfall

17.5.1 Alternaria leaf blight, *Alternaria cucumerina*

Time for concern: When the canopy closes
Affected crop(s): All cucurbits, especially netted melons
Key characteristics: Symptoms first appear on the upper surface of crown leaves as small, circular spots ¼ inch in diameter and later enlarge to show a target-like pattern of rings. See Reference 1 and http://hdl.handle.net/1813/43273.

Management Option	***Guideline***
Scouting/thresholds	As the plants begin to run (vine types) or flower (bush types), chose five representative sites. At each site, inspect two older leaves on each of five plants. Record the number of infected plants. A total of 50 leaves should be inspected per field. After the row closes (vine types) or fruit that have set begin to enlarge (bush types), substitute five plant areas. Examine ten leaves per area. Calculate and record the percent of plants infected. Threshold: symptoms found on one leaf per 25 to 50 leaves sampled. When the disease threshold is met, spray on a seven to ten day schedule. Use a higher rate or shorter interval under severe disease pressure. See Reference 3.
Resistant varieties	No resistant varieties are available.
Crop rotation	Minimum two years without cucurbits.
Site selection	Sites with good air movement are preferred to reduce the period of leaf-wetness. Schedule overhead irrigation to allow sufficient drying of foliage prior to extended evening wet periods. Avoid planting next to other cucurbits.
Seed selection/treatment	Because the organism may be seedborne, purchase fungicide-treated seeds.
Postharvest	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 a currently viable management option.

Compound(s) Alternaria Leaf Blight

Product Name (Active Ingredient) (Class of Compounds)	**Product Rate**	**PHI (Days)**	**REI (Hours)**	**Field Use EIQ**	**Comments**
*Aprovia Top (*difenoconazole + benzovindiflupyr*) (Group 3 + 7)	10.5-13.5 fl oz/acre	0	12	3.1-4	No more than 2 consecutive, 4 max applications.
Bravo Weather Stik (*chlorothalonil*) or OLP (Group M5)	2-3 pts/acre	0	12	42.2-63.2	
Cabrio EG (*pyraclostrobin*) (Group 11)	12-16 oz/acre	0	12	4.1-5.4	No consecutive applications. In NYS, no aerial application within 100 feet of aquatic habitats.
Champ Formula 2F (*copper hydroxide*) or OLP (Group M1)	1.33 pts/acre	0	48	17.3	
Endura 70 WDG (*boscalid*) (Group 7)	6.5 oz/acre	0	12	7.5	No consecutive applications. No more than 4 max applications.
Inspire Super (*difenoconazole + cyprodinil*) (Group 3 + 9)	16-20 fl oz/acre	7	12	10.3-12.9	No more than 2 consecutive applications.
ManKocide (*mancozeb + copper hydroxide*) (Group M3 + M1)	2-3 lb/acre	5	48	38.3-57.5	No more than 8 max applications.
Manzate ProStik (*mancozeb*) or OLP (Group M3)	2-3 lb/acre	5	24	38.6-57.9	No more than 8 max applications.
*†Miravis Prime (*fludioxonil + pydiflumetofen*) (Group 12 + 7)	9.2 - 11.4 fl oz/acre	1	12		
Pristine (*pyraclostrobin + boscalid*) (Group 11 + 7)	12.5-18.5 oz/acre	0	12	7.9-11.7	No consecutive applications. In NYS, no aerial application within 100 feet of aquatic habitats.

19.7 Weed Management

Key characteristics: Weed fact sheets provide a good color reference for common weed identification. See (http://nysipm.cornell.edu/factsheets/weeds/default.asp). See Chapter 4 for information on scouting/thresholds, site selection, cultivation, and banding of herbicides.

Management Option	*Guideline*
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 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

Timing			
PPI	**PreE**	**PostE**	**Product Name** *(active ingredient, weight of active per unit of herbicide, group number)* *Notes*
	X		**Roundup WeatherMAX** *(glyphosate, 5.5 lb/gal, group 9)* *Rate:* 1-1.4 pts/acre weeds < 6” tall, 1.4-2 pt/ac weeds > 6" tall *AI per acre:* 0.69-0.96 lbs/acre weeds < 6” tall, 0.96-1.4 weeds > 6" tall *PHI:* 14 *REI:* 4 *Field Use EIQ:* 7.8-10.9 *Comments:* 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

Timing			
PPI	**PreE**	**PostE**	**Product Name** *(active ingredient, weight of active per unit of herbicide, group number)* *Notes*
		X	***ΔSelect Max** *(clethodim, 0.97 lb/gal, group 1)* *Rate:* 9-16 fl oz/acre *AI per acre:* 0.068-0.12 lbs/acre *PHI:* 14 *REI:* 24 *Field Use EIQ:* 1.3-2.2 *Comments:* Leaf lettuce only. For control of numerous annual and perennial grasses. DO NOT apply more than 0.5 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.

* 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 4L	prometryn	4 L	100-620 (SLN NY-140007)
Chateau SW	flumioxazin	51 WDG	59639-99
Clarity	dicamba	4 EC	7969-137
Command 3 ME	clomazone	3 ME	279-3158
Curbit EC	ethalfluralin	3 EC	34704-610
Devrinol 50-DF	napropamide	50 DF	70506-36
*†Dual Magnum	metolachlor	7.62 E	100-816
*†Dual II Magnum	metoachlor	7.64 E	100-818
Eptam 7-E	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 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
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 SLN NY 130006
Roundup WeatherMAX	glyphosate	5.5 L	524-537
Sandea	halosulfuron	75 DF	81880-18-10163
Satellite HydroCap	pedimethalin	3.8 ME	70506-230
*ΔSelect Max	clethodim	.97 L	59639-132
*†Sharpen	saflufenacil	2.85WS	7969-278

Table continues on next page.