2023
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.

2023 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 (December 2022). 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 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: Potato field in Steuben County, New York. (*Photo by: Margie Lund, Extension Vegetable Specialist, Cornell Vegetable Program*)

Chapter 1 – Integrated Crop and Pest Management

1.1 Background

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

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

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

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

1.2 Practicing IPM

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

1.3 IPM Components

1.3.1 Monitoring (Scouting)

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

1.3.2 Forecasting

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

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

1.3.3 Thresholds

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

1.3.4 Management Tactics

Appropriate management tactics to control pests include cultural, biological, and physical controls, as well as chemical controls when they are needed. Taking advantage

Chapter 2 – Disease Management

2.1 General Principles

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

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

2.2 Diagnosis of Disease

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

2.3 Disease Management Tactics

2.3.1 Crop Rotation and Tillage

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

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

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

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

Owing to a reduction in nitrifying bacteria by the fumigants, at least 50% of the nitrogen in the initial fertilizer application should be in the nitrate form.

A number of factors have a pronounced effect on the success or failure of soil fumigation. Six are given below.

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

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

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

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

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

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

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

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

		Crop																							
Fungicide (*active ingredient*)	FRAC Group	Asparagus	Bean, Dry	Bean, Snap	Beet	Broccoli	Brussels sprouts	Cabbage	Cabbage, Chinese	Carrot	Cauliflower	Cucumber	Eggplant	Lettuce and Endive	Melon	Onion, Dry bulb	Onion, GB	Peas	Pepper	Potato	Pumpkin, W. Squash	Spinach	Summer Squash	Sweet Corn	Tomato	Watermelon
Actigard (*acibenzolar-S-methyl*)	P 01					X^{7}	X^{7}	X^{7}	X^{7}		X^{7}	X		H^{7} L^{7}	X	X^{7}			Chili 14		X	X^{7}	X		X^{14}	X
Agri-mycin 17 (*streptomycin*)	**25**																		X	X					X	
Aliette WDG (*fosetyl-Al*)	P 07					X^{3}	X^{3}	X^{3}	X^{3}		X^{3}	$X^{0.5}$		X^{3}	$X^{0.5}$	X^{3}					$X^{0.5}$	X^{3}	$X^{0.5}$		X^{14}	$X^{0.5}$
Andiamo 230 (*tetraconazole*)	**3**		X^{14}																							
*†Aproach (*picoxystrobin*)	**11**		X^{14}																							
Apron XL (*mefenoxam*), seed	**4**		X		X													X						X		
Aprovia Top (*difenoconazole + benzovindiflupyr*)	**3 + 7**		X^{14}	X^{14}								X	X		X	X^{7}	X^{7}	X^{14}	X		X		X		X	X
Blocker 4F (*PCNB*), application method varies	14					X	X	X	X		X									X						

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

Table 3.2.1 Some commonly used insecticides on vegetables.

Not all registered products are listed in this table or in crop sections.

		Crop																				
Insecticide ***(Active Ingredient)***	*Mode of Action*[1]	Asparagus	Bean, Dry	Bean, Snap	Beet	Broccoli	Brussels sprouts	Cabbage	Cabbage, Chinese	Carrot	Cauliflower	Cucumber, Melon, and Watermelon	Eggplant	Lettuce and Endive	Onion, dry bulb	Onion, green bunching	Peas	Pepper	Potato	Pumpkin and S/W Squash	Spinach	Sweet Corn	Tomato, field
*ΔProclaim (*emamectin benzoate*)	*6*					X	X	X	X		X												
*Provado (*imidacloprid*)	*4*			X		X	X	X	X		X		X					X	X				X
Radiant SC (*spinetoram*)	*5*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sevin XLR (*carbaryl*)	*1A*	X	X	X		X	X	X	X	X	X	X	X						X	X		X	X
*Vendex 50W (*fenbutin-oxide*)	*12*												X										
*†ΔVoliam Xpress (*chlorantraniliprole + lambda-cyhalothrin*)	*3, 28*		X	X		X	X	X	X		X	X		X				X	X	X		X	X
*Warrior II with Zeon Technology (*lambda-cyhalothrin*)	*3*		X	X		X	X	X	X		X	X			X			X	X	X		X	X
Xentari (*Bt var. aizawai*)	*11*					X	X	X	X		X												

* Restricted-use pesticide † = Not for use in Nassau/Suffolk Counties Δ = Rate or other application restrictions apply.

[1]Modes of Action

[2]Except cucumber

[3] Head lettuce only.

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

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

Chapter 4 – Weed Management

4.1 General Principles

Weeds reduce yield and quality of vegetables by competing directly for light, nutrients, and water. Weeds can 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. See the Cornell Weed Identification web site (https://blogs.cornell.edu/weedid/).

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]	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
*Reflex (*fomesafen*)	*14*		X	X																					
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

Table continued on next page.

Chapter 5 – Wildlife Damage Management

5.1 Deer

5.1.1 Nonchemical Alternatives

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

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

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

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

5.1.2 Repellents

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

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

5.2 Woodchucks

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

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

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

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

Chapter 6 – Pesticide Information and Use

6.1 Pesticide Classification and Certification

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

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

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

Information on pesticide certification and classification is available from your Cornell Cooperative Extension office (cce.cornell.edu/localoffices), regional NYSDEC pesticide specialist (www.dec.ny.gov/about/558.html), the Pesticide Applicator Training Manuals (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 Properly

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

6.2.1 Plan Ahead

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

6.2.2 Move Pesticides Safely

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

6.2.3 Personal Protective Equipment and Engineering Controls

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

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

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

6.2.4 Avoid Drift, Runoff, and Spills

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

- all nozzles are clean and free from obstruction (note: clean with a soft brush or airline – don't damage nozzles by using wires or pins)
- all nozzles deliver to within + or - 5% of the manufacturer's chart value

Action: Always ensure the correct nozzles and operating pressure are selected before use. Have two or three sets of nozzles in stock to meet different spray qualities at different volume rates. Inspect nozzles throughout the season to avoid faults which could prove both costly and damaging to the environment if they develop unchecked. Using water only, set to 'spray' at the specified pressure and collect the output from each nozzle in turn for a period of 60 seconds. Record each output and replace those outside the 5% tolerance around the manufacturer's chart value.

6.12.3 Calibration

Equipment must be calibrated accurately if correct dosages are to be applied. The sprayer must give the right total gallonage per acre, and each nozzle must deliver its share of that total. The pesticide may be ineffective or may be wasted if it is not applied as accurately as possible. Over application results in more costly operation or causes off-target environmental contamination. Under application of materials may result in poor control and could require repeated applications which will be more costly.

The United States Department of Agriculture and the Environmental Protection Agency recommend that pesticides be applied within ten percent of the intended rate of application. Frequent checks of sprayer and tractor performance should be made to ensure that the machines are operating as expected. As the label rates of pesticide required per acre decrease, it is even more important that operators give tractor and sprayer performance proper attention.

There are many different ways to calibrate liquid sprayers. Some growers actually spray a measured acre; others spray a small part of an acre; others keep the sprayer stationaryand collect and measure the spray for a certain number of minutes. If the initial results show that the volume of water is too low, the volume delivered can be increased by reducing tractor speed or changing to larger nozzle tips. If the volume is too high, the reverse can be done. It is not desirable (or even possible) to make drastic changes in pressure in order to adjust volume per acre. Most nozzles have a relatively narrow pressure range in which they will operate properly.

Only clean water should be used when calibrating sprayers. Calibration requires knowledge of the amount of material 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 the tank half filled with water on the same type of terrain that the sprayer will be operated on.

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

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

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

Your figures:

Tractor gear ___________ Engine revs.___________

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

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 x 10^5 reading of 100 to 125, although muck soils can tolerate a somewhat higher amount without injury. Leaching and keeping the soil in the flat moist are partial solutions for high soluble salt problems. Refer to Section 9.6.1 for information on soil sterilization and control of diseases.

9.2.2 Artificial Mixtures

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

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

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

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

Chapter 10 – Postharvest Handling

10.1 Background

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

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

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

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

10.2 Harvest Considerations

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

10.3 Clean Surfaces and Containers

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

10.4 Washing and Chlorination

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

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

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

Chlorine in the wash water is often inactivated when the wash water becomes dirty. Use filtering devices to remove soil and organic material, and check the chlorine concentration often. Produce should be subjected to the chlorinated wash from one to ten minutes. After it is removed, allow it to drain for several minutes before packing. There are other chemicals beside chlorine that can

Chapter 11 – Organic Vegetable Production

11.1 Organic Certification

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

11.2 Organic Farm Plan

An organic farm plan is central to the certification process. The farm plan describes production, handling, and record-keeping systems, and demonstrates to certifiers an understanding of organic practices for a specific crop. The process of developing the plan can be very valuable in terms of anticipating potential issues and challenges, and fosters thinking of the farm as a whole system. Soil, nutrient, pest, and weed management are all interrelated on organic farms and must be managed in concert for success. Certifying organizations may be able to provide a template for the farm plan. The following description of the farm plan is from the NOP web site:

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

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

11.3 Soil Health

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

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

11.4 Cover Crops

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

A certified organic farmer is required to plant certified organic cover crop seed. If, after contacting at least three suppliers, organic seed is not available, then the certifier may allow untreated conventional seed to be used. Suppliers should provide a purity test for cover crop seed.

Chapter 14 – Beets

14.1 Varieties

Varieties differ in root color, shape and time to maturity. Below are commonly used varieties in New York:

- Avalanche (white)
- Chioggia Guardsmark (red and white rings)
- Detroit Dark Red (red)
- Falcon (red)
- Merlin (red)
- Red Ace (red)
- Ruby Queen (red)
- Touchstone Gold (yellow)
- Crosby (greens or roots)

See Disease Resistant Beet varieties at www.vegetables.cornell.edu.

14.2 Planting Methods

The beet is a cool-season, root vegetable that tolerates frosts and mild freezes. Seed germinates at soil temperatures between 40° and 90°F, optimally 50° to 85°F. Because beet plants withstand cool growing conditions and the seed germinates at soil temperatures below 50°F, planting can begin in late April. The best root quality and color are obtained when the crop matures during cool temperatures and bright sunlight. When grown under warm conditions, root color is lighter, sugar content is lower, and color zoning in roots is more pronounced than under cool conditions.

Beets are biennial, normally producing an enlarged root the first growing season and, after a cold induction period, a seedstalk. Premature seedstalk initiation can occur if the plants are subjected to two to three weeks of temperatures below 45°F after they have several true leaves. Plants of some varieties initiate premature seedstalks more readily than others; many of the newer varieties are less sensitive to this problem.

Well-drained, sandy loam to silt loam soil is preferred for best growth and quality. Beets can also be grown on muck soil, but weed control is difficult. A soil with good structure is highly recommended because beets respond favorably to aeration.

A beet seedball normally contains from two to four viable seeds, and more plants than seedballs may result, especially if conditions are favorable for germination. Larger seedballs contain more seeds than do smaller seedballs. Desired plant spacing is obtained by adjusting seeding rate. Plant spacing is a strong determinant of final root size and shape. Plants are sometimes thinned for the fresh market. See Table 14.2.1 Recommended spacing.

Table 14.2.1 Recommended spacing.

Type	Row(in inches)	In-row seeding rate[1] (in pounds per acre)
Fresh-market	16-24	8-10
Processing	16-24	15-25

[1]The lower rate of seed is sown early so the roots will size quickly for early harvest

14.3 Fertility

Use lime to maintain a pH of 6.5 to 6.8 in all parts of the field. Beets are especially sensitive to low pH and should not be planted in soil with a pH below 6.0. Because beets use boron inefficiently, this element must be applied to most soils in New York. A boron deficiency causes plant foliage to be stunted and distorted, and roots exhibit symptoms of internal breakdown. Boron is less available in high pH soils. Apply 2-1/2 to 5 pounds of boron per acre mixed with fertilizer. Use the lower rate if nutrients have been applied two to three times in the previous five years. Boron is toxic to many plants and care must be taken when developing a rotation plan. Beans, peas, and cucurbits are especially sensitive to boron residues. See Table 14.3.1 for the recommended rates of nitrogen, phosphorus, and potassium.

14.4 Harvesting

For fresh market, the crop is usually ready for harvest in 60 to 85 days. The processing crop is harvested in 90 to 110 days, but a thick plant stand can be held in the field for a relatively long time. Processing beets are usually harvested until mid-November. Yields for the fresh market range from eight to 12 tons per acre and approximately 15 to 20 tons per acre for processing.

Machine harvesters are used for the processing crop and for the market crop that is sold topped. Beets for bunching are handpicked and tied. Topped beets can be stored for several months at temperatures near 32°F and 95 to 98 percent relative humidity.

Table 14.3.1 Recommended application rate of nutrients based on soil tests.[1,2]

N (pounds/acre)	P_2O_5 (pounds/acre)			K_2O (pounds/acre)			Comments
	Soil Phosphorus Level			Soil Potassium Level			
	low	med.	high	low	med.	high	
150-175	***150***	***100***	***50***	***300***	***200***	***100***	***Total recommended***
25-50	75	25	0	225	150	50	Broadcast and disk-in.
25	75	75	50	75	75	50	Band place with planter.
50	0	0	0	0	0	0	Apply three weeks after planting
50	0	0	0	0	0	0	Apply eight weeks after planting

16.5 Disease Management

See Table 4 in the Appendix for biofungicide options. Be sure to read the label to determine that the proper crop and pest combination is listed.

16.5.1 Leaf blights (Alternaria leaf blight (a.k.a. late blight), *Alternaria dauci*; Cercospora leaf blight (early blight), *Cercospora carotae*; and Bacterial leaf blight, *Xanthomonas campestris* pv. *carotae*)

Time for concern: See individual pathogens listed below.
Key characteristics: These pathogens can cause severe blight on carrot leaves and petioles during a prolonged period of wet and warm weather. All three pathogens can be seedborne. Alternaria - dark brown to black irregular spots first appear at the margin of the leaflets. Lesions on the petioles and stems are dark brown and girdle the stems. As the disease progresses, entire leaflets may shrivel and die. Lesions are more prevalent on older foliage. Alternaria is most severe in late August and September. Cercospora - small, circular, tan or gray spots with a dead center first appear along the margins of the leaves causing the leaves to curl. As the lesions increase in number and size, the entire leaflet dies. The fungus attacks younger leaves. Because it develops rapidly in hot and humid weather, it is likely to occur in July and early August. Bacterial - small yellow areas appear on the leaflets. The centers of the lesions become brown and dry and are often surrounded by a yellow halo. See (hdl.handle.net/1813/43265).

Management Option	***Guideline***
Scouting/thresholds	Record the type of leaf blight and severity of infection. When 25% of leaves are infected with Alternaria and/or Cercospora, make the first fungicide application. No threshold has been established for bacterial blights. Once detected, a spray program should begin.
Resistant varieties	Great differences exist in the tolerance of carrot varieties, thus scouting for disease threshold must be done by variety. Contact your Cornell Cooperative Extension office for details.
Crop rotation	Minimum 2 to 3 year rotation out of carrots is effective against the three diseases.
Soil maintenance	Well-fertilized soil reduces the development of Alternaria. A nitrogen application made in mid-August or early September may promote foliage development. An alternative method of applying nitrogen is to add sprayable urea to each fungicide spray.
Seed selection/treatment	All three diseases can be seed-borne. Plant only treated and/or certified seed. Check seed package and ask seed company for this information. Companies that test seed include Eurofins BioDiagnostics. Hot water treatment is worth considering for non-treated seed that could be contaminated. It kills pathogens inside seed as well as on the surface. This treatment may reduce germination and vigor when done incorrectly, and may not eradicate the pathogen from heavily infested lots. See Reference 1.
Postharvest	Crop debris should be destroyed as soon as possible to remove this source of inoculum for other plantings and to initiate decomposition.
Sanitation	This is not a currently viable management option.

Compound(s) Leaf blights

Product Name (Active Ingredient) (Class of Compounds)	**Product Rate**	**PHI (Days)**	**REI (Hours)**	**Field Use EIQ**	**Comments**
Bravo Weather Stik (*chlorothalonil*) or OLP (Group M 05)	1.5-2 pts/acre	0	12	31.6 - 42.2	Labeled for Alternaria and Cercospora leaf blights.
Bravo Zn (*chlorothalonil*) (Group M 05)	2.25-2.75 pts/acre	0	12	33.8 - 41.3	
Cabrio EG (*pyraclostrobin*) (Group 11)	8-12 oz/acre	0	12	2.7 - 4.1	*See comment below*
Labeled for Alternaria and Cercospora leaf blights. No more than 2 consecutive applications. In NYS, no aerial application within 100 feet of aquatic habitats.					

Compound(s) Verticillium wilt

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
*Ally 33 (*allyl isothiocyanate + chloropicrin*) (Group NC +)	see label	Refer to Label	Refer to Label	Not Available	Soil fumigant; training required. *EIQ: 42.43*
Dominus (*allyl isothiocyanate*) (Group NC)	10-40 gal/acre	-	120	Not Available	Biofumigant
*Tri-Pic 100 (*chloropicrin*)	175 or 300-350 lb/acre soil treatment	0	Refer to Label	Not Available- 14702	Rate varies with application method. Soil fumigant; training required. *EIQ: 42.43*
*Vapam HL (*metam sodium*)	37.5-75 gal/acre	-	see label	3494.8 - 6989.6	Soil fumigant; training required.

* Restricted-use pesticide.

18.6 Insect Management

18.6.1 Flea beetles, primarily the eggplant flea beetle, *Epitrix fuscula;* potato flea beetle, *Epitrix cucumeris*; and tobacco flea beetle, *Epitrix hirtipennis*

Time for concern: June through August. Early stages of plant development
Key characteristics: The eggplant and potato flea beetles are black and about 1/16 inch long. The tobacco flea beetle is similar in size, yellowish brown in color, and has a dark band across its wings. Damage appears as small holes in the leaves caused by adults feeding. The larvae of all three species are thin, white worms from 1/8 to 1/3 inch long. Larvae feed on the roots of plants but do not cause serious injury. See hdl.handle.net/1813/43272.

Management Option	*Guideline*
Scouting/thresholds	Scout for flea beetles after setting plants in the field. Pay close attention to field edges. Thresholds: **Height of plant (in inches)** — **Number of flea beetles (per plant)** <3 — 2 3-6 — 4 >6 — 8 Apply insecticides when thresholds are met.
Natural enemies	The species and effectiveness of natural enemies are not known.
Resistant varieties	No resistant varieties are available.
Postharvest	Deep plowing after harvest may reduce overwintering populations.
Sanitation	Keep fields free of weeds
Crop rotation, Site selection, and Seed selection/treatment	These are not currently viable management options.

Compound(s) Flea beetles

Product Name (Active Ingredient) (Class of Compounds)	Product Rate	PHI (Days)	REI (Hours)	Field Use EIQ	Comments
*†Actara (*thiamethoxam*) (Group 4A)	2.0-3.0 oz/acre	0	12	1 - 1.6	Foliar application only.
*Admire Pro Systemic Protectant (*imidacloprid*) (Group 4A)	7.0-10.5 fl oz/acre	21 for soil apps, 0 for foliar	12	7.1 - 10.7	Soil application only.

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.

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 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

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:* For control of numerous annual and perennial grasses that are not stressed. DO NOT apply more than 0.485 lb ai/acre/year. Application on LONG ISLAND is restricted to no more than 0.25 lb ai/acre/year. Always use 0.25% v/v non-ionic surfactant (NIS). 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. Separate sequential applications by 14 days. Do not make more than 4 applications per acre per year.

* 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	4 SC	100-1131
Caparol 4L	prometryn	4 L	100-620 (SLN NY-140007)
Chateau EZ	flumioxazin	41.4 SC	59639-221
Chateau SW	flumioxazin	51 WDG	59639-99
Clarity	dicamba	4 EC	7969-137
Command 3 ME	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 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
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