2019 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.

2019 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.

Cover photo: Beet field in Batavia, Genesee County, NY. (*Photo by: Sarah Pethybridge, Cornell Plant Pathology and Plant Microbe Biology, SIPS)*

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 fungicides by crop.

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
Actigard (*acibenzolar-S-methyl*), SAR	P1					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
Aliette (*fosetyl-Al*)	33					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}	$X^{0.5}$
Apron XL (*mefenoxam*), direct seeding	**4**		X		X													X						X		
Kaligreen MilStop (*potassium bicarbonate*)	**NC**											X	X		X				X		X		X		X	X
Blocker 4F (*PCNB*), application method varies	14		X	X		X	X	X	X		X									X						
Bravo, Echo, OLP (*chlorothalonil*)	M5	X^{190}	X^{14}	X^{7}		X^{7}	X^{7}	X^{7}	X^{7}	X	X^{7}	X			X	X^{7}	X^{14}			X^{7}	X		X	$X^{g,14}$	X	X
Cabrio EG (*pyraclostrobin*), no aerial	**11**				X	X	X	X	X	X	X	X	X	X	X	X^{7}	X^{7}		X		X	X	X		X	X
Captan (seed)	M4		X	X		X	X	X			X							X								
Catamaran (*chlorothalonil + potassium phosphite*)	M5 + 33		X^{14}	X^{7}		X^{7}	X^{7}	X^{7}	X^{7}	X	X^{7}	X			X					X^{7}	X		X		X	X
Cease (*B. subtilis*), Gr. Hs.	Bio				X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X
Contans (*Coniothyrium minitans*)	**Bio**							X		X				X						X						
Copper, fixed[a] (see end of table)	M1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CruiserMaxx Legumes (*thiamethoxam + mefenoxam + fludioxonil*), seed	Ins + **4** + **12**		X	X														X								
†CruiserMaxx Potato (*thiamethoxam + fludioxonil*), seed piece	Ins + **12**																			X						
Curzate 60DF (*cymoxanil*), seed piece and foliar	**27**											X^{3}		He^{3} Le^{1}	X^{3}					X^{14}	X^{3}	X^{1}	X^{3}		X^{3}	X^{3}
Decree (*fenhexamid*), Gr. Hs., Tsp.	**17**											X	X	X					X						X	
*Dithane DF, Manzate, Penncozeb, *Roper DF (*mancozeb*), seed piece, in-furrow, foliar	M3	X^{180}				$X^{f,7}$		$X^{f,7}$				X^{5}		$X^{f,10}$	X^{5}	X^{7}			$X^{f,7}$	X^{3}	X^{5}		X^{5}	X^{7}	X^{5}	X^{5}

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.

Most insecticides include an IRAC group number on the front page of the label. Alternating between insecticides with different group numbers will help avoid the development of resistant insect populations.

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
*†Actara (*thiamethoxam*)	*4A*				X	X	X	X	X	X	X	X	X	X				X	X	X	X		X
*Admire Pro Systemic Protectant (*imidacloprid*)	*4*		X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X		X
*Agri-Mek 0.15EC (*abamectin*)	*6*											X	X					X	X	X	X		X
Assail 30SG (*acetamiprid*)	*4A*			X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X
Avaunt (*indoxacarb*)	*22*					X	X	X	X		X		X	X				X	X			X	X
*Baythroid XL (*beta-cyfluthrin*)	*3A*		X		X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
Beleaf 50 SG (*flonicamid*)	*9C*					X	X	X	X		X	X	X	X				X	X	X			X
*†ΔCoragen (*chlorantraniliprole*)	*28*					X	X	X	X		X	X	X	X				X	X	X	X		X
*Diazinon AG 500 (*diazinon*)	*1B*			X	X	X	X	X	X	X	X	X[2]		X	X	X					X		X
*Dimethoate (*dimethoate*)	*1B*		X	X		X	X	X	X		X	X		X			X	X	X		X		X
DiPel DF (*Bt var. kurstaki*)	*11*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Entrust SC (*spinosad*)	*5*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fulfill (*pymetrozine*)	*9A*	X				X	X	X	X		X	X	X	X				X	X	X	X		X
*ΔGladiator (*zeta-cypermethrin + avermectin*)	*3/6*											X	X	X				X	X	X			X
*Hero *(bifentrhin + zeta-cypermethrin*)	*3A*			X		X	X	X	X		X		X					X			X	X	
Javelin (*Bt var. kurstaki*)	*11*					X	X	X	X		X			X									
*Lannate LV (*methomyl*)	*1A*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
*Lorsban Advanced (*chlorpyrifos*)	*1b*					X	X	X	X		X				X							X	
Movento (*spirotetramat*)	*23*					X	X	X	X		X		X	X				X	X		X		X
*Mustang MAXX (*zeta-cypermethrin*)	*3A*		X	X		X	X	X	X		X		X	X	X			X			X	X	
*Orthene 97 (*acephate*)	*1B*		X	X			X				X			X				X					
*†Platinum 75SG (*thiamethoxam*)	*4A*				X	X	X	X	X	X	X	X	X	X				X	X	X	X		X
*Pounce (*permethrin*)	*3A*	X				X	X	X	X		X	X		X	X	X			X	X		X	
*ΔProclaim (*emamectin benzoate*)	*6*					X	X	X	X		X												

Chapter 4 – Weed Management

4.1 General Principles

Weeds reduce yield and quality of vegetables by competing directly for light, nutrients, and water and by interfering with harvest operations. Early-season competition is most critical and a major emphasis on control should be made in this period. Weed control requires good management practices in all phases of production. Because there are so many different kinds of weeds, they cannot be managed by a single method. The first step in managing weeds is identification. Some of the common problem weeds in New York State are highlighted below.

4.1.1 Problem Weeds in Vegetable Production

Galinsoga. 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. Galinsoga 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. It continues to form seed until it is killed by frost. Fresh seed drops onto the soil surface and soon sprouts because there is little or no dormancy. The new seedlings begin to flower at the fifth or sixth node, and the cycle is repeated. Three to five generations per season are often observed in Ithaca, New York. Cultivation is only partially helpful because Galinsoga roots quickly and easily reestablish themselves from cut stems and uprooted plants unless conditions are very dry for several days after cultivation.

Many herbicides used on vegetables are only slightly helpful for control of Galinsoga. Ineffective chemicals include *†Dacthal, *Eptam, Prefar, and Treflan. Several herbicides are extremely toxic to Galinsoga: *AAtrex, *†Dual, Lorox, and metribuzin.

Velvetleaf. This robust, annual weed is increasing rapidly in upstate New York areas. 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. Seedlings 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 seedlings that emerge late. Unfortunately, even late seedlings can produce mature seeds before frost.

Although several herbicides are active against velvetleaf, they usually do not provide season-long control. Fields should also be cultivated. *AAtrex, Basagran, *Eptam, Lorox, Prowl, and 2,4-D have activity against velvetleaf. Herbicides such as *†Dacthal, Prefar, *†Dual, and Treflan, however, have little activity regardless of timing.

Nightshade. Nightshade, a warm-season summer-annual weed, is becoming a problem in New York. Eastern black nightshade (*Solanum ptycanthum*) is the most common and widespread species, but hairy nightshade (*Solanum sarracoides*) is predominant in some areas. These weeds are particularly problematic in tomato, potato, snap bean, and dry bean fields. Few herbicides currently registered for vegetable crops effectively control nightshade. Therefore, to stop an infestation, it is important to identify the weed and eradicate it before the plants produce seeds. *AAtrex, used in sweet corn, will control nightshade, and thus corn can be used as a rotational crop to reduce control problems in other vegetables. The acetamides (*†Dual) suppress nightshades. Additional research will be required, however, to determine the effectiveness of these herbicides in controlling the different nightshade species.

Quackgrass. This common perennial problem grass is controlled most efficiently by a combination of chemicals and tillage. Check specific crop guidelines for control.

Nutsedge (nutgrass). Tubers do not sprout 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, forming the first tubers as the days shorten slightly in July. As days shorten more sharply in August and September, tuber formation is greatly accelerated. In the fall, even small plants form tubers.

In many vegetable crops, even temporary control is difficult. Furthermore, reducing the severity of a heavy infestation or eliminating nutsedge from a field is difficult because tubers may last four or more years after they have formed. Fortunately, nutsedge is sensitive to dense shade, and successful control measures need to capitalize on this characteristic. For example, when planted early at close spacing, most pumpkins and squash provide the shade needed. For dry and snap beans, potatoes, and sweet corn, nutsedge can be controlled by selective herbicides. See specific crop information. Some general suggestions include: use heavy crop shading if possible; plant crops at close spacings; cultivate between rows until crop foliage takes over; 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, delay planting and treatment until tubers have sprouted. Herbicides do not damage dormant tubers. Both cultural practices and herbicides are needed; neither can do the job alone.

Perennial broadleaf weeds. Perennial broadleaf weeds such as bindweed, Canada thistle, horsenettle, and milkweed are not easily controlled while vegetable crops are growing. Cultivation alone is only partially adequate, and effective herbicides are very damaging to crops.

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.

	Crop																								
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
*†Optill (*saflufenacil + imazethapyr*)	*14/2*																X								
*†Outlook (*dimethenamid*)	*15*		X													X			X				X		
Permit (*halosulfuron*)	*2*		X																				X		
Poast (*sethoxydim*)	*1*	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Prefar (*bensulide*)	*8*						X	X	X		X	X	X	X	X			X				X		X	X
Prowl H_2O (*pendimethalin*)	*3*	X	X	X						X						X	X	X	X				X	X	
Raptor (*imazamox*)	*2*		X	X													X								
*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

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: $\text{GPM} = \dfrac{ \times \times }{5940} = \dfrac{}{5940} =$ 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. Nozzle performance should be checked frequently because

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 13 – Beans – Dry, Snap, and Lima

13.1 Varieties

See Tables of Disease Resistant Varieties at: http://vegetablemdonline.ppath.cornell.edu/Tables/TableList.htm

13.2 Planting Methods

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

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

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

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

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

13.3 Fertility

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

13.4 Harvesting

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

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

Table 13.2.1 Recommended spacing of dry and snap beans.

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

13.5.1 Anthracnose (*Colletotrichum lindemuthianum* and other species)

(Primarily a problem on dry beans. Has become less common at least partly due to improved seed treatments)
Time for concern: From seeding stage through the end of harvest
Key characteristics: Seedlings have dark brown to black, sunken lesions on cotyledons and stems. Under moist conditions, small, pink masses are produced in the lesions. On the pods, small, reddish brown to black blemishes and distinct, circular, reddish brown lesions are typical symptoms. A prolonged wet period is necessary for the fungus to establish infection. The fungus is seed- or soilborne. See http://hdl.handle.net/1813/43258.

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

Compound(s) ***Common name*** **(Group no.)** Trade name	Rate/A Product	PHI (days)	REI (hours)	Field Use EIQ	Comments
azoxystrobin **(dry, snap, & lima beans) (Group 11)**					
Quadris F or OLP	6.0-15.5 fl oz	0 Succulent 14 Dry	4	2.3-6.0	Do not apply more than 1 sequential foliar application of Quadris or other Group 11 fungicide before alternating with a fungicide that has a different Group #.
azoxystrobin + chlorothalonil **(dry beans) (Group 11 + M5)**					
Quadris Opti	1.6-2.4 pt	14 Dry	12	29.5-44.3	For use on dry beans (including lima) only. Do not make more than 2 applications before alternating with a non-Group 11 fungicide.
azoxystrobin + propiconazole **(dry, snap, and lima beans) (Group 3 + 11)**					
Quilt	14 fl oz	7 Succulent 14 Dry	12	4.9	Apply either product no more than 3 times to a crop. Apply in alternation with other fungicides with different Group # (MOA).
Quilt Xcel	10.5 - 14 fl oz	7 Succulent 14 Dry	12	6.1-8.1	
chlorothalonil **(drybeans) (Group M5)**					
Bravo Weather Stik or OLP 6 lb/gal	1.38- 2 pt	14 Dry	12	27.9-40.4	For use on dry beans only. Note WPS provisions that apply for 6.5 days after an application because chlorothalonil is a severe eye irritant.
difenoconazole + benzovindiflupyr **(Group 3 + 7)**					
*Aprovia Top	10.5-11 fl oz	14	12	–	See comments below.
Apply no more than 2 times. Alternate with a non-Group 7 fungicide to manage resistance. Apply with a spreading/ penetrating type adjuvant. Seasonal max is 0.46 lb difenoconazole/A/year. Aerial application is prohibited in NYS.					
fluxapyroxad + propiconazole **(Group 7 + 11)**					
*†Priaxor	4-8 fl oz	7 Snap, lima 21 Dry	12	–	Do not apply more than twice. Make no more than 2 sequential applications of *†Priaxor or *†Priaxor and other Group 7 or 11 fungicide. Do not mix with crop oil concentrate or an EC formulation.

14.7 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	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 weeds. 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 beets
Cultivation	Cultivation is essential in beet weed control. See IPM Fact Sheet 102FSNCT on mechanical weed control (www.vegetables.cornell.edu/weeds/newcultivationmech.pdf.) Also see SARE Sustainable Agriculture Network Handbook Series Book 2 "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 useful in beet production. Herbicide banding can result in up to 60 percent savings in herbicide costs. Contact CCE for more information.

Compounds: (*Listed from earliest to latest application timing.)*

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		***†DUAL MAGNUM** (*s-metolachlor, 7.62 lb/gal, group 15*) *Weeds Controlled:* annual grasses, yellow nutsedge, galinsoga, nightshade species, and selected broadleaves *Rates (per acre):* 0.67 pt *AI per acre (lbs/acre):* .64 *PHI (days):* 60 *REI (hours):* 24 *Field Use EIQ:* 12.3 *Comments:* **Not for use in Nassau and Suffolk Counties.** This is a Special Local Need (SLN) registration that requires indemnification due to a wider range of *†Dual Magnum rates and application methods than the federal Section 3 registration. Growers must have a copy of the SLN label in their possession and sign off on the indemnification if they choose to follow the recommendations in these guidelines. SLN indemnified labels and the indemnification agreement can be found by logging in at www.farmassist.com. (New users must create an account.) Once logged in, labels are available under the products menu at the top of the screen under "Indemnified Labels." If difficulties are encountered in using the website, click the support link at the top of the FarmAssist web page to contact Syngenta. Make a single application after planting, before the crop or weeds emerge. This may be made as either a broadcast or banded application. Do not use on soils having less than 1.5% or greater than 10% organic matter.
	X	**X**	***†NORTRON SC** (*ethofumesate, 4 lb/gal, group 16)* *Weeds Controlled:* common lambsquarters, nightshades, pigweeds, wild buckwheat *Rates (per acre):* pre-emergence: 60 fl. oz.; post-emergence: 5.25-10.5 fl. oz. *AI per acre (lbs/acre):* pre-emergence: 1.9.; post-emergence: 0.16-0.32 *PHI (days):* See comments *REI (hours):* 12 *Field Use EIQ:* pre-emergence: 40.7.; post-emergence: 3.6-7.1. *Comments:* **This is a 24 (c) (Special Local Needs) registration.** Can be applied pre and post (maximum 2 times/season). May not be applied past the 8 leaf stage. Do not feed or graze treated crop within 60 days of application. May not exceed 96 fl. oz./season.
		X	**AIM EC** (*carfentrazone, 2 lb/gal, group 14*) *Rates (per acre):* 0.8-1.6 fl oz application *AI per acre (lbs/acre):* .0125-.025 *PHI (days):* 0 *REI (hours):* 12 *Field Use EIQ:* 0.2-0.5 *Comments:* **May be used only as a hooded, row middle application.** Sprayers must be designed to prevent **ANY** contact with the crop and may not be operated at more than 5 MPH. Special care must be taken when operating on uneven ground. See product label for additional precautions.

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	7969-45-66330
Broadloom	bentazon	4 L	70506-306
Buctril	bromoxynil	2 EC	264-437
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
Option	foramsulfuron	25 G	264-685
*†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