INTRODUCTION

This guide for organic production of carrots provides an outline of cultural and pest management practices and includes topics that have an impact on improving plant health and reducing pest problems. It is divided into sections, but the interrelated quality of organic cropping systems makes each section relevant to the others.

The guide attempts to compile the most current information available, but acknowledges that effective means of control are not available for some pests. More research on growing crops organically is needed, especially in the area of pest management. Future revisions will incorporate new information, providing organic growers with a complete set of useful practices to help them achieve success.

This guide uses the term Integrated Pest Management (IPM), which like organic production, emphasizes cultural, biological, and mechanical practices to minimize pest outbreaks. With limited pest control products available for use in many organic production systems, an integrated approach to pest management is essential. IPM techniques such as identifying and assessing pest populations, keeping accurate pest history records, selecting the proper site, and preventing pest outbreaks through use of crop rotation, resistant varieties and biological controls are important to producing a high quality crop.

1. GENERAL ORGANIC MANAGEMENT PRACTICES

1.1 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 (Link 4) operating in New York can be found on the New York State Department of Agriculture and Markets Organic Farming Resource Center web page (Link 5). See more certification and regulatory details under Section 4.1 *Certification Requirements* and Section 10: *Using Organic Pesticides.*

1.2 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 (Link 6). The National Sustainable Agriculture Information Service, (formerly ATTRA), has produced a guide to organic certification that includes templates for developing an organic farm plan (Link 7). The Rodale Institute has also developed resources for transitioning to organic and developing an organic farm plan (Link 8).

2. 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 breakdown 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 most 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 especially the lesion nematode. 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 by Fred Magdoff and Harold Van Es, 2010 (Link 10). For additional information, refer to the Cornell Soil Health website (Link 11).

3. 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, with their cultural requirements carefully considered including 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. See Tables 3.1 and 3.2 for more information on specific cover crops and Section 8: *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 conventional seed to be used. Suppliers should provide a purity test for cover crop seed. Always inspect the seed for contamination with weed seeds and return if it is not clean. Cover crop seed is a common route for introduction of new weed species onto farms. Carrot growers should be particularly alert for clover seed contaminated with wild carrot.

3.1 Goals and Timing for Cover Crops

Adding cover crops regularly to the crop rotation plan can result in increased yields of the subsequent cash crop. Goals should be established for choosing a cover crop; for example, the crop can add nitrogen, smother weeds, or break a pest cycle. The cover crop might best achieve some of these goals if it is in place for the entire growing season. If this is impractical, a compromise might be to grow the cover crop between summer cash crops. Allow two or more weeks between cover crop incorporation and cash crop seeding to permit decomposition of the cover crop, which will improve the seedbed and help avoid any unwanted allelopathic effects on the next crop. Another option is to overlap the cover crop and the cash crop life cycles by overseeding, interseeding or intercropping the cover crop between cash crop rows at final cultivation. An excellent resource for determining the best cover crop for your situation is Northeast Cover Crop Handbook, by Marianne Sarrantonio (Reference 6) or the Cornell online decision tool to match goals, season, and cover crop (Link 9).

Leaving cover crop residue to remain on the soil surface might make it easier to fit into a crop rotation and will help to conserve soil moisture, but some of the nitrogen contained in the residue will be lost to the atmosphere, and total organic matter added to the soil will be reduced. Turning under the cover crop will speed up the decomposition and nitrogen release from the crop residue.

3.2 Legume Cover Crops

Legumes are the best cover crop for increasing available soil nitrogen. Legumes have symbiotic bacteria called rhizobia, which live in their roots and convert atmospheric nitrogen gas in the soil pores to ammonium, a form of nitrogen that plant roots can use. When the cover crop is mowed, winter killed or incorporated into the soil, the nitrogen is released and available for the next crop. Because most of this nitrogen was taken from the air, there is a net nitrogen gain to the soil (see Table 3.1). Assume approximately 50 percent of the fixed nitrogen will be available for the crop to use in the first season, but this may vary depending on the maturity of the legume, environmental conditions during decomposition, the type of legume grown, and soil type.

It is common to inoculate legume seed with rhizobia prior to planting, but the inoculant must be approved for use in organic systems. Request written verification of organic approval from the supplier and confirm this with the organic farm certifier prior to inoculating seed.

3.3 Non-Legume Cover Crops

Barley, rye grain, rye grass, Sudangrass, wheat, oats, and other grain crops left on the surface or plowed under as green manures or dry residue in the spring are beneficial because these plants take up nitrogen that otherwise might be leached from the soil, and release it back to the soil as they decompose. If incorporated, allow two weeks or more for decomposition prior to planting to avoid the negative impact on stand establishment from actively decomposing material. Three weeks might not be enough if soils are very cold. In wet years, this practice may increase slug damage.

3.4 Biofumigant Cover Crops

Certain cover crops have been shown to inhibit weeds, pathogens, and nematodes by releasing toxic volatile chemicals when tilled into the soil as green manures and degraded by microbes or when cells are broken down by finely chopping. Degradation is quickest when soil is warm and moist. These biofumigant cover crops include Sudangrass, sorghum-sudangrasses, and many in the brassica family. Varieties of mustard and arugula developed with high glucosinolate levels that maximize biofumigant activity have been commercialized (e.g. Caliente brands 199 and Nemat).

Attend to the cultural requirements of the cover crops to maximize growth. Fertilizer applied to the cover crops will be taken up and then returned to the soil for use by the cash crop after the cover crop is incorporated. Biofumigant cover crops like mustard should be allowed to grow to their full size, normally several weeks after flowering starts, but incorporated before the seeds become brown and hard indicating they are mature. To minimize loss of biofumigant, finely chop the tissue early in the day when temperatures are low. Incorporate immediately by tilling, preferably with a second tractor following the chopper. Lightly seal the soil surface using a culti-packer and/or 1/2 inch of irrigation or rain water to help trap the volatiles and prolong their persistence in the soil. Wait at least two weeks before planting a subsequent crop to reduce the potential for the breakdown products to harm the crop, also known as phytotoxicity. Scratching the soil surface before planting will release remaining biofumigant. This biofumigant effect is not predictable or consistent. The levels of the active compounds and suppressiveness can vary by season, cover crop variety, maturity at incorporation, amount of biomass, fineness of chopping, how quickly the tissue is incorporated, soil microbial diversity, soil tilth, and microbe population density.

Resources:
Cover Crops for Vegetable Growers: Decision Tool (Link 9).
Northeast Cover Crops Handbook (Reference 6).
Cover Crops for Vegetable Production in the Northeast (Reference 7).
Crop Rotation on Organic Farms: A Planning Manual (Link 11a).

Table 3.1 Leguminous Cover Crops: Cultural Requirements, Nitrogen Contributions and Benefits.

Species	Planting Dates	Life Cycle	Cold Hardiness Zone (Link 1)	Heat	Drought	Shade	pH Preference	Soil Type Preference	Seeding (lb/A)	Nitrogen Fixed (lb/A)[a]	Comments
				Tolerances							
CLOVERS											
Alsike	April-May	Biennial/ Perennial	4	5	5	6	6.3	Clay to silt	4-10	60-119	+Endures waterlogged soils & greater pH range than most clovers
Berseem	Early spring	Summer annual/ Winter annual[b]	7	6-7	7-8	5	6.5-7.5	Loam to silt	9-25	50-95	+Good full-season annual cover crop
Crimson	Spring	Summer annual/ Winter annual[b]	6	5	3	7	5.0-7.0	Most if well-drained	9-40	70-130	+Quick cover +Good choice for overseeding (shade tolerant) + Sometimes hardy to zone 5.
Red	Very early spring or late summer	Short-lived perennial	4	4	4	6	6.2-7.0	Loam to clay	7-18	100-110	+Strong taproot, good heavy soil conditioner +Good choice for overseeding (shade tolerant)
White	Very early spring or late summer	Long-lived perennial	4	6	7	8	6.2-7.0	**Loam to clay**	6-14	≤130	+Good low maintenance living cover +Low growing +Hardy under wide range of conditions
SWEET CLOVERS											
Annual White	Very early spring	Summer annual[b]	NFT	6-7	6-7	6	6.5-7.2	Most	15-30	70-90	+Good warm weather smother & catch crop +Rapid grower

Table 3.1 Leguminous Cover Crops: Cultural Requirements, Nitrogen Contributions and Benefits.

											+High biomass producer
Biennial White and Yellow	Early spring-late summer	Biennial	4	6	7-8	4	6.5-7.5	Most	9-20	90-170	+Deep taproot breaks up compacted soils & recycles nutrients +Good catch crop +High biomass producer
OTHER LEGUMES											
Cowpeas	Late spring-late summer	Summer annual[b]	NFT	9	8	6	5.5-6.5	Sandy loam to loam	25-120	130	+Rapid hot weather growth
Fava Beans	April-May or July-August	Summer annual[b]	8	3	4	NI	5.5-7.3	Loam to silty clay	80-170 small seed 70-300 lg seed	71-220	+Strong taproot, good conditioner for compacted soils + Excellent cover & producer in cold soils +Efficient N-fixer
Hairy Vetch	Late August-early Sept.	Summer annual/ Winter annual	4	3	7	5	6.0-7.0	Most	20-40	80-250 (110 ave.)	+Prolific, viney growth +Most cold tolerant of available winter annual legumes
Field Peas	March-April OR late summer	Winter annual/ Summer annual[b]	7	3	5	4	6.5-7.5	Clay loam	70-220	172-190	+Rapid growth in chilly weather

NI=No Information, NFT=No Frost Tolerance. Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. [a] Nitrogen fixed but not total available nitrogen. See Section 8 for more information. [b] Winter killed. Reprinted with permission from Rodale Institute www.rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook (Reference 6).

Table 3.2 Non-leguminous Cover Crops: Cultural Requirements and Crop Benefits

SPECIES	PLANTING DATES	LIFE CYCLE	COLD HARDINESS ZONE	HEAT	DROUGHT	SHADE	PH PREFERENCE	SOIL TYPE PREFERENCE	SEEDING (LB/A)	COMMENTS
				--TOLERANCES--						
Brassicas e.g. mustards, rapeseed	**April or late August-early Sept.**	Annual / Biennial [b]	6-8	4	6	NI	5.3-6.8	Loam to clay	5-12	+Good dual purpose cover & forage +Establishes quickly in cool weather +Biofumigant properties
Buckwheat	Late spring-summer	Summer annual [b]	NFT	7-8	4	6	5.0-7.0	Most	35-134	+Rapid grower (warm season) +Good catch or smother crop +Good short-term soil improver for poor soils
Cereal Rye	August-early October	Winter annual	3	6	8	7	5.0-7.0	Sandy to clay loams	60-200	+Most cold-tolerant cover crop +Excellent allelopathic weed control +Good catch crop +Rapid germination & growth +Temporary N tie-up when turned under
Fine Fescues	Mid March-mid-May OR late Aug.-late Sept.	Long-lived perennial	4	3-5	7-9	7-8	5.3-7.5 (red) 5.0-6.0 (hard)	Most	16-100	+Very good low-maintenance permanent cover, especially in infertile, acid, droughty &/or shady sites
Oats	Mid-Sept-	Summer	8	4	4	4	5.0-6.5	Silt &	110	+Rapid growth

Table 3.2 Non-leguminous Cover Crops: Cultural Requirements and Crop Benefits

	early October	annual[b]						clay loams			+Ideal quick cover and nurse crop
Ryegrasses	August-early Sept.	Winter annual (AR)/ Short-lived perennial (PR)	6 (AR) 4 (PR)	4	3	7 (AR) 5 (PR)	6.0-7.0	Most	14-35	+Temporary N tie-up when turned under +Rapid growth +Good catch crop +Heavy N & moisture users
Sorghum-Sudangrass	Late spring-summer	Summer Annual [b]	NFT	9	8	NI	Near neutral	NI	10-36	+Tremendous biomass producers in hot weather +Good catch or smother crop +Biofumigant properties

NI-No Information, NFT-No Frost Tolerance. AR=Annual Rye, PR=Perennial Rye.
Drought, Heat, Shade Tolerance Ratings: 1-2=low, 3-5=moderate, 6-8=high, 9-10=very high. [b] Winter killed. Reprinted with permission from Rodale Institute www.rodaleinstitute.org M. Sarrantonio. (1994) Northeast Cover Crop Handbook. (Reference 6).

4. FIELD SELECTION

For organic production, give priority to fields with excellent soil tilth, high organic matter, good drainage and airflow.

4.1 Certifying Requirements

Certifying agencies have requirements that affect field selection. Fields cannot be treated with prohibited products for three years prior to the harvest of a certified organic crop. Adequate buffer zones are required between certified organic and conventionally grown crops. Buffer zones must be a barrier, such as a diversion ditch or dense hedgerow, or be a distance large enough to prevent drift of prohibited materials onto certified organic fields. Determining what buffer zone is needed will vary depending on equipment used on adjacent non-certified land. For example, use of high-pressure spray equipment or aerial pesticide applications in adjacent fields will increase the buffer zone size. Pollen from genetically engineered crops can also be a contaminant. An organic crop should not be grown near a genetically engineered crop of the same species. Check with your certifier for specific buffer requirements. These buffers commonly range between 20 to 250 feet depending on adjacent field practices.

4.2 Crop Rotation Plan

A careful crop rotation plan is the cornerstone of organic crop production because it allows the grower to improve soil quality and proactively manage pests. Although growing a wide range of crops complicates the crop rotation planning process, it ensures diversity in crop residues in the soil, and a greater variety of beneficial soil organisms. Individual organic farms vary widely in the crops grown and their ultimate goals, but some general rules apply to all organic farms regarding crop rotation. Rotating individual fields away from crops within the same family is critical and can help minimize crop-specific disease and non-mobile insect pests that persist in the soil or overwinter in the field or field borders. Pests that are persistent in the soil, have a wide host range, or are wind-borne, will be difficult to control through crop rotation. Conversely, the more host specific, non-mobile, and short-lived a pest is, the greater the ability to control it through crop rotation. The amount of time required for a crop rotation is based on the particular pest and its severity. Some particularly difficult pests may require a period of fallow. See specific recommendations in the disease and insect sections of this guide (Sections 11, 12, 13). Partitioning the farm into management units will help to organize crop rotations and ensure that all parts of the farm have sufficient breaks from each type of crop.

A well-planned crop rotation is key to weed management. Short season crops such as lettuce and spinach are harvested before many weeds go to seed, whereas vining cucurbits, with their limited cultivation time and long growing season, allow weeds to go to seed before harvest. Including short season crops in the rotation will help to reduce weed populations provided the field is cleaned up promptly after harvest. Other weed reducing rotation strategies include growing mulched crops, competitive cash crops, short-lived cover crops, or crops that can be intensively cultivated. Individual weed species emerge and mature at different times of the year, therefore alternating between spring, summer, and fall planted crops helps to interrupt weed life cycles.

Cash and cover crop sequences should also take into account the nutrient needs of different crops and the response of weeds to high nutrient levels. High soil phosphorus and potassium levels can exacerbate problem weed species. A cropping sequence that alternates crops with high and low nutrient requirements can help keep nutrients in balance. The crop with low nutrient requirements can help use up nutrients from a previous heavy feeder. A fall planting of a non-legume cover crop will help hold nitrogen not used by the previous crop. This nitrogen is then released when the cover crop is incorporated in the spring. See Section 5: *Weed Management,* and Section 3: *Cover Crops* for more specifics.

Rotating crops that produce abundant organic matter, such as hay crop and grain-legume cover crops, with ones that produce less, such as vegetables, will help to sustain organic matter levels and promote good soil tilth (see Section 2: *Soil Health* and Section 8: *Crop and Soil Nutrient Management*). Carrots generally have a lower nutrient requirement (Table 4.2.1). Growing a cover crop, preferably one that includes a legume (unless the field has a history of *Pythium* or *Rhizoctonia* problems), prior to or after a carrot crop, will help to renew soil nutrients, improve soil structure, and diversify soil organisms. Deep-rooted crops in the rotation to help break up compacted soil layers.

Table 4.2.1 Crops Nutrient Requirements

	Nutrient Needs		
	Lower	**Medium**	**Higher**
Crop	bean beet carrot herbs pea radish	cucumber eggplant brassica greens pepper pumpkin spinach chard squash winter squash	broccoli cabbage cauliflower corn lettuce potato tomato

From NRAES publication *Crop Rotation on Organic Farms: A Planning Manual.* Charles L. Mohler and Sue Ellen Johnson, editors, (Link 11a).

Table 4.2.2 Potential Interactions of Crops Grown in Rotation with Carrot

Crops in Rotation	**Potential Rotation Effects**	**Comments**
Leek, onion, garlic, potato, rutabaga, turnip, radish,	Causes a *decline* in **soil structure**	Root crops tend to reduce soil structure due to the additional soil disturbance during harvest. Grow “soil building” crops before and after a root crop.
Spring oat cover crop	*Improves* **soil structure**	a spring oat cover crop (often planted with field pea) helps control weeds and restore soil structure after plantings of root crops.
Field pea cover crop	*Improves* soil **nitrogen** *Decreases* **weed pressure**	A spring planted field pea cover crop (often planted with oats) controls weeds and helps restore nitrogen after late harvested crops such as parsnip
Short season crops such as lettuce and spinach	*Decreases* **weed pressure**	Plant short season crops prior to carrot to reduce weed pressures.
Onion, leek	*Increase* in **weed pressure**	Weed control is difficult in crops such as carrots and onions and can lead to heavy weed pressures in subsequent crops.
Bean, lettuce	*Increase in* **Sclerotinia white mold**	Sclerotinia has a wide host range of other crops and weeds. Rotate to a grain crop or sweet corn.
Many hosts	*Reduces* **germination**	Germination may be reduced if carrot is planted in fields with a history of *Pythium* or *Rhizoctonia.*
Carrot, celery, potato, celeriac, parsnip	*Increase* in **Root knot nematode**	2-year rotation sequences with these crops should be avoided to reduce root knot nematodes.

Excerpt from Appendix 2 of Crop Rotation on Organic Farms: A Planning Manual. Charles L. Mohler and Sue Ellen Johnson, editors. (Link 11a)

4.3 Pest History

Knowledge about the pest history for each field to plan a successful cropping strategy. Germination may be reduced in fields with a history of *Pythium* or *Rhizoctonia.* Avoid fields that contain heavy infestations of perennial weeds such as nutsedge, bindweed, and quackgrass as these weeds are particularly difficult to control. One or more years focusing on weed population reduction, using cultivated fallow and cover cropping, may be needed before organic crops can be successfully grown in those fields.

Susceptible crops should not be grown in fields with a history of Sclerotinia white mold without a rotation of several years to sweet corn or grain crops or treatment with Contans to reduce fungal sclerotia in the soil after an infected crop is harvested. Fields heavily infested with root rot pathogens should also be rotated to a grain crop to reduce infection potential.

If nematodes are not a problem, it is beneficial to grow several short season crops, such as spinach and lettuce, the year before carrots, so that weeds can be killed before they go to seed, but keep a record of root disease severity as it might be increasing.

Carrots are very sensitive to infection by root-knot nematode, *Meloidogyne hapla*, and severe yield losses can result from reduced marketability. It is important to know whether or not this nematode is present in the field in order to develop long-term crop rotations and cropping sequences that either reduce the populations in heavily infested fields or minimize their increase in fields that have no to low infestation levels. Refer to Section 12 for more information on nematodes.

4.4 Drainage and Soil Texture

Most fungal and bacterial pathogens need free water on the plant tissue or high humidity for several hours in order to infect. Any practice that promotes leaf drying or drainage of excess water from the root zone will minimize favorable conditions for infection and disease development. Fields with poor air movement, such as those surrounded by hedgerows or woods, result in leaves staying wet. Plant rows parallel to the prevailing winds, which is typically in an east-west direction, and avoid overcrowding to promote drying of the soil and reduce moisture in the plant canopy.

Carrots need good air and soil drainage for disease management. Obtaining long, straight, smooth roots is difficult. Light-textured soils that contain few stones or well-drained muck soils are preferred.

5. WEED MANAGEMENT

Weed management can be one of the biggest challenges on organic farms, especially during the transition and the first several years of organic production. To be successful, weed management on organic farms must take an integrated approach that includes crop rotation, cover cropping, cultivation, and planting design, based on an understanding of dominant weed biology and ecology of dominant weed species. A multi-year approach that includes strategies for controlling problem weed species in a sequence of crops will generally be more successful than attempting to manage each year's weeds as they appear. Relying on cultivation alone to manage weeds in an organic system is a recipe for disaster.

5.1 Record Keeping

Scout and develop a written inventory of weed species and severity for each field. Accurate identification of weeds is essential. Management plans should focus on the most challenging and potentially yield-limiting weed species in each field, being sure to emphasize options that do not exacerbate other species that are present. Alternating between early and late-planted, and short and long season crops in the rotation can help minimize buildup of a particular weed or group of weeds with similar life cycles or growth habits, and will also provide windows for a variety of cover crops.

5.2 Weed Management Methods

Planting and cultivation equipment should be set up on the same number of rows to minimize crop losses and damage to carrot roots during cultivation. It may be necessary to purchase specialized equipment to successfully control weeds in some crops. See resources at the end of this section to help fine-tune your weed management system. Weed fact sheets provide a good color reference for common weed identification. See Cornell Weed Ecology and Rutgers Weed Gallery websites (Links 21-22).

Plant carrots after a fallow year where frequent harrowing was possible, or after a year of short season crops such as spinach and lettuce, where weeds were killed before they went to seed. Be aware that while helping to reduce weeds, using these crops in a rotation can contribute to disease problems. Let the field fallow again before planting. Till the soil, and prepare a rough but settled seedbed. Let the weeds emerge, and then till at a shallow depth to kill them.

Prepare the seed bed, firm it and let a second flush of weeds emerge until the largest are about 1 inch. Go over the bed with a flame weeder, with speed set slow enough to kill every weed. Flaming is recommended because it maintains bed structure and leaves weed seeds undisturbed. The investment in a flame weeder will pay for itself in the first year by saving on hand labor.

Plant carrots and wait about 9 days until just before carrots emerge. Flame the bed again to destroy new weed growth one last time prior to carrot seed emergence.

Allow carrots to become established in this weed free environment. Before weeds reach 2", begin cultivating with a belly mounted or steered rear mounted cultivator. Use vegetable knives adjusted as close to the row as your steering ability permits. Whatever is not cultivated will need hand weeding therefore cultivating as close to the rows possible is recommended. For later cultivations, switch to 4" sweeps next to the row using them to throw soil into the row. This will bury small weed seedlings and keep the shoulder of the carrot root covered.

Resources

Steel in the Field (Link 20).
Cornell Weed Ecology website: (Link 21).
Rutgers University, New Jersey Weed Gallery: (Link 22).
University of Vermont videos on cultivation and cover cropping: (Link 23).
ATTRA Principles of Sustainable Weed Management for Croplands: (Link 24).
New Cultivation Tools for Mechanical Weed Control in Vegetables (Link 25).

6. RECOMMENDED VARIETIES

Variety selection is important both for the horticultural characteristics specified by the processor and the pest resistance profile that will be the foundation of a pest management program. If the field has a known pest history, Table 6.1 can help determine which varieties might be resistant or tolerant of the problem. Consider the market when choosing varieties, selecting those with some level of disease resistance if possible.

A certified organic farmer is required to plant certified organic seed. If, after contacting at least tree suppliers, organic seed is not available for a particular variety, then the certifier may allow untreated conventional seed to be used.

Blunt-tipped Nantes varieties are preferred for sliced, processed products, and blocky Chantenay or Danvers types are used for diced products.

Table 6.1 Disease Resistance of Selected Carrot Varieties.

Variety	Alternaria Leaf Blight	Cercospora	Bacterial leaf blight	Aster yellows	Cavity Spot	Bolting	Cracking	Carrot type
Abledo[4]						X		Early. Dicing
Abundance								Dicing (new)
Amtou				R				
Bercaro				R				
Bergen[4]	2	1						Slicing (new)
Big Sur	X							
Bolero	1,R	1,R						Slicing
Camarillo[4]								Dicing (new)
Campbells 1364[4]								Dicing
Canterbury[4]								Dicing (new)
Carson[4]	R	2,R						Dicing (new)
Charger				R				
Cordoba[4]	X	X						Dicing (new)
Eagle[4]	3	2						Slicing
El Presidente				R				
Enterprise[4]	X			R				Slicing
Gold King				R				
Growers Choice				R				
GT 26 Dicer				R				
Hi Color 9				R				
Impak				R				
Magnum[4]	X							Slicing
Nanton				R				
Napa		3					X	Slicing
Nevada	X							Slicing
Nimrod				R				
Primecut 59	X	X		R				Slicing
Prodigy								Slicing/Dicing (new)
Prospector				R				
PY 60				R				
Recoleta	X	3		R				Slicing/Dicing (new)
Revo				R				
Rona				R				
Royal Chantenay				R				
Scarlet Nantes				R				
Scarlet Nantes ST				R				
Sierra				R				
Sirocco	X, R	R		R				Slicing

Variety	Alternaria Leaf Blight	Cercospora	Bacterial leaf blight	Aster yellows	Cavity Spot	Bolting	Cracking	Carrot type
Six Pak				R				
Spearhead				R				
Tajoe				R				
Texsun				R				
Top Cut 93[4]	X	X						Slicing
Toudo				R				
Triple Play 58				R				
Upper Cut 25	X							Slicing

1 = highly resistant, 2 = moderately resistant, 3 = no resistance (in replicated trials from NY), 4 Varieties currently grown in NY
X = resistance indicated in seed catalog. R = resistant based on assessments done in Wisconsin. Empty cells indicate that no information is available

7. PLANTING METHODS

The earliest recommended planting date in New York for untreated carrot seed is late April. The crop is harvested in late September and October. To avoid bacterial blight and other diseases, only clean seed should be planted. Seeds can be tested for vigor at a New York State Seed Testing Laboratory (Link 27). Carrots are a cool-season crop that can tolerate light frosts. Good quality roots (judged by length, shape, and color) develop when soil temperature is between 60° and 70°F. At warmer temperatures, the roots will be shorter, and internally the color will be lighter orange.

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

The length of carrot roots is determined within the first few weeks after germination because the taproot quickly penetrates deep into the soil. If the young taproot is injured, it will become branched and forked, making the root unmarketable. Excessive soil moisture, insects, diseases, nematodes, and soil compaction can all markedly affect root quality. Wet soil near harvest will cause the roots to become rough and promote root rot diseases. Obtaining long, straight, smooth roots is difficult. Light-textured soils that contain few stones or well-drained muck soils are preferred. Primary tillage should be fairly deep, but care must be taken not to impair soil structure by working the soil when wet. Use of raised beds, which tend to increase drainage, aeration, and total depth of tilled soil, can improve the length and shape of roots.

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

Table 7.1 Recommended spacing

Type	Row (inches)	Seed In-Row	Pounds /Acre
Nantes	18-36	1.5”	2 to 3
Chantenay or Danvers	18-36	1.5”	1 to 2

8. CROP & SOIL NUTRIENT MANAGEMENT

To produce a healthy crop, soluble nutrients must be available from the soil in amounts that meet the minimum requirements for the whole plant. The total nutrient needs of a crop are much higher than just the nutrients that are removed from the field when that crop is harvested. All of the roots, stems, leaves and other plant parts require nutrients at specific times during plant growth and development. The challenge in organic systems is balancing soil fertility to supply these required plant nutrients at a time and at sufficient levels to support healthy plant growth. Restrictions in any one of the needed nutrients will slow growth and can reduce crop quality and yields.

Organic growers often speak of feeding the soil rather than feeding the plant. A more accurate statement is that organic growers focus their fertility program on feeding soil microorganisms rather than the plant. Soil microbes decompose organic matter to release nutrients and convert organic matter to more stable forms such as humus. This breakdown of soil organic matter occurs throughout the growing season, depending on soil temperatures, water availability and soil quality. The released nutrients are then held on soil particles or humus making them available to crops or cover crops for plant growth. Amending soils with