The Northeast Crop Production Manual

A Crop-by-Crop Guide to Vegetable Production for Small- and Mid-Size Growers

Jean-Paul Courtens
Philia Farm
Johnstown, N.Y.

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Mention of Specific Crop Varieties

Crop variety recommendations in the *Northeast Crop Production Manual* are based on the knowledge and experience of the author and collaborators. Recommended varieties can change over time, so consult with local experts or suppliers when making variety selections.

Available Online

Both this guide and its companion, the *Northeast Harvest Manual,* are available online at www.sare.org/resources/northeast-crop-production-harvest-manual. Not available in print.

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Also available online at www.sare.org/resources/northeast-crop-production-harvest-manual.

Letter from the Author

In the 1990s, when Roxbury Farm (now known as Roxbury Farm CSA) was in its pioneering phase, apprentices were a key part of our workforce. One of our apprentices, Katie Smith (currently the co-owner of the Farm at Miller's Crossing in Hudson, N.Y.), complained, correctly, that it was difficult to learn how to farm through on-the-job instruction alone. Her sentiment reflected a broad dissatisfaction among apprentices with the lack of intentional training within apprenticeship programs. During my own farmer training in the Netherlands, our apprenticeships were guided by our schools and were supported by a strong theoretical foundation, so I knew we could do much better. In response, David Inglis of Mahaiwe Harvest CSA and I called together 13 other farmers in the Hudson and Pioneer Valleys for a meeting to reflect on what should be offered to an apprentice working on our farms. As our collective knowledge proved greater than what we could offer individually on our farms, the Collaborative Regional Alliance for Farmer Training (CRAFT) was born.

To provide our apprentices with better guidance, I decided to write down all the daily instructions for growing and harvesting our crops. This process spanned several years, and resulted in the first edition of the Roxbury Farm Crop and Harvest Manuals, published in 2001. Because I wrote them for our apprentices and employees, they referenced tools and methods specific to our farm. At the end of their employment, apprentices kept their own copies, which helped them during their own pioneering phase in building a new farm.

Over time, word got out about the manuals, and when apprentices from the other farms came for a CRAFT visit, many requested a copy. To offset printing costs and make them easier to share, I made the manuals available through our website. At conferences, people would often stop me and thank me for having made the manuals available, telling me it was one of the most important tools available to them in the early phase of their farming career.

The manuals went through several editions and continued to be written exclusively from the Roxbury Farm perspective. Roxbury Farm grew from a 5-acre vegetable operation in 1990 to a 370-acre farm producing vegetables, beef, and lamb for 1,100 CSA shareholders in 2005. In 2014, I left Roxbury Farm–which continues to thrive today under new ownership–to start a small-scale farm from scratch in the foothills of the Adirondacks, named Philia Farm. Here, our goal is to conduct research on the optimal practices in vegetable and vegetable seed production while providing fresh produce to a small local community.

This experience gave me a renewed appreciation of how scale affects production practices, and when I reread the manuals, I realized their limitations. In response, I applied for and received a grant from Northeast SARE in 2020 to update and broaden the manuals (project FNE20-950). This involved polling 60 exemplary farmers in New England and beyond about their production and harvest practices. Vegetable specialists from Cornell Cooperative Extension helped with the questionnaire and interpretation of the results. They also reviewed the final copies to ensure compliance with the Food Safety Modernization Act. This expansion prompted me to rename them the Northeast Crop Production and Harvest Manuals.

The *Northeast Crop Production Manual* includes tips on planning rotations, preparing the soil, planting and transplanting, and managing pests. It's most useful for organic farmers in the Northeast, and also for farmers in other parts of the country with a similar four-season climate. The *Northeast Harvest Manual* addresses the timing and methods for harvesting crops, along with post-harvest handling and storage considerations.

The information in the latest edition of the manuals is written to be relevant to both mid-size and smaller-scale operations.

While the new manuals continue to be a bit Northeast-centric, I have tried to keep farmers all over the United States in mind. New links provide in-depth knowledge on specific topics or practices. These links were carefully selected to appeal to a broad audience.

I extend my sincere gratitude to all the participating farmers, extension specialists, and SARE staff for their support and valuable contributions over the years. We hope the following information will help your operation become more successful and allow you to adopt the most sustainable practices in your operation.

Jean-Paul Courtens
Philia Farm, Johnstown, N.Y.

Arugula

Eruca sativa (*Brassicaceae* or cabbage family)

Soil preparation and rotation

- To avoid insect and disease pressure, arugula should not follow other crops in the Brassica family for 1–3 years.
- Spring arugula does well after a winter cover crop of oats and peas, oats by itself (in the Northeast or Midwest, a mid- to late-September seeding date will see oats reach about a foot in height), or when no cover crop was planted the previous fall.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like arugula don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine, firm seedbed weeks before planting. This encourages weeds to germinate and provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	20–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial
- Astro for regular arugula; Belluzia for wild arugula

Direct seeding information in 5- or 6-foot beds

For full-grown arugula, plant rows are 7–9 inches apart; for baby arugula, use close row spacings or broadcast the seed. Wild arugula seed is very small and the following recommendations do not apply.

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	30	3 or 4	¼		Use spreader shoe
Sutton Jr.	10–20	20–40	6	¼		Drive 1 mph
Jang	5	12–24	YYJ-12 or X24	¼	12 hole: front 14/rear 9; 24 hole: front 14/rear 10	

Soil temperature and days to germinate

Soil temperature	40°	50°	60°	70°	75°
Days to germinate	23	5	3	2	1

Seeding time and successions

- Start planting in the spring as soon as you've prepared the ground. Arugula won't germinate below a soil temperature of 40°. Optimum germination is 75°. Optimum growing conditions are 65°–75°.
- Depending on the location, plant successions in the spring 10–12 days apart for a continuous harvest, and shorten the intervals down to a weekly planting. As a general rule, don't plant the next succession until the cotyledons have fully emerged, or at the first true leaf stage.
- Arugula bolts due to longer days and high temperatures. Therefore, avoid late spring plantings that will mature in summer.
- Resume with weekly plantings when nights have cooled off, which is in August through September in the northern United States. Plant weekly successions until 3–4 weeks before the first frost.
- Greenhouse or high-tunnel growers plant wild arugula every 4 days for continual harvest. As mentioned above, early plantings require longer intervals to avoid a situation where several successions are ready to harvest at the same time.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- You shouldn't need to hand weed if you plant arugula in clean ground at the correct population and row distance.

Disease and insect protection

- Bacterial leaf spot is seed borne. If possible, use a hot water treatment before planting. This won't work for wild arugula as the seed is too small and exposure to hot water will make it sterile.
- Flea beetles:
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn–based product like Entrust.
    - Fall-planted arugula doesn't need any protection after the third generation of flea beetles, which is around September 1 in the Northeast. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant another short-season vegetable crop like lettuce or spinach after early arugula.
- For later dates, work under any harvest remains to avoid insect or pathogen build up, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested arugula with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.
- November-harvested arugula doesn't allow for the establishment of a cover crop. Any attempt to work the soil late in the fall without establishing a cover crop can cause erosion. While late-season arugula serves poorly as a cover crop, it's better than bare ground.

Baby Bok Choy

Brassica rapa (*chinensis* group) (*Brassicaceae* or cabbage family)

Soil preparation and rotation

- Total nutrient uptake is 165 lbs. of N, 10 lbs. of P and 208 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Incorporate compost and amendments, and plant Joi Choi or Mei Qing Choi in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Li Ren Choi, Red Choi, Fujo Chomi, Mei Qing Choi, Win-Win Choi

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	65°–85°	Cool	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Number of successions

- Spring: Baby bok choy doesn't do well during hot and dry weather. Plant cabbage 4–5 weeks before the last frost date. Depending on your markets, plant each week for continuous harvest from spring to early summer. In New York, this is limited to 2–3 successions.
- Fall: Baby bok choy does best as a fall crop. In New York, seeding is resumed in July on a weekly basis until 4–5 weeks before the first frost for continuous harvest until November.

Transplant readiness indicators

- Plants should easily come out of their cells. Plants should generally not be older than 5 weeks.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3–4	10–12 inches	To avoid bottom rot, do not plant too deep.	Bok choy does not like to be transplanted, so take great care of plants and plant in the afternoon.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe or hand weed in between plants.
- For a second cultivation, only use side knives to avoid crop damage.

Frost, disease and insect protection

- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products in conjunction with a spinosyn-based product to avoid resistance buildup.
- *Rhizoctonia*, or bottom rot, can be an issue with Chinese cabbage and bok choy. Don't allow lower parts of plants to be in contact with the soil, and apply long rotations that avoid other members of the Brassica family. Good preventive measures include transplanting when the soil is at least 55°, reducing irrigation, and dipping plants in *Trichoderma harzianum*, as in the product RootShield.
- Basal stem rot (*Erwinia carotovora*), not to be confused with *Rhizoctonia*, is caused by insects eating at the basal stem, but damage by cultivation can also help bring on this disease. Avoid aggressive cultivation in bok choy production.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can transplant a short-season vegetable crop like lettuce after early-planted bok choy.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested bok choy with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Basil

Ocimum basilicum (*Lamiaceae* or mint family)

Soil preparation and rotation

- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Basil does best when planted in raised beds; it likes warm, well-drained soil.
- Basil should not follow basil or many common cut-flower species. It does best on clean ground and thrives under good, natural fertility.
- If direct seeded, Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like basil don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures. If transplanted, some plant debris is acceptable as long as it doesn't interfere with weed control.
- Create a fine and firm seedbed when direct seeding basil. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Iowa variety trial
- Genovese, Italian Large Leaf, Sweet Thai. Some newer varieties like Prospera show some resistance to downy mildew.

Greenhouse guidelines

- EZ Seeder seeding plate #9

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°	75°	Withhold water	3–4 seeds to a cell. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Seeding time and successions

- Seed in a greenhouse 4 weeks before the last frost if you intend to protect the basil with row covers after planting. Basil is very sensitive to frost and cold weather. Don't expose it to cold nighttime temperatures.
- Plant successions 10–14 days apart for continued harvest, with the last seeding in July for the northern United States. Early plantings require longer intervals to avoid a situation where several successions are ready to harvest at the same time. If you intend to harvest multiple times from the same plant, you can reduce the number of successions accordingly.

Transplanting tips

- Soil temperature should be at least 60°.

- Plants should pull from trays easily. Plants should generally not be older than 4 weeks. If they get too tall, transplanting gets more difficult as they can get stuck inside the tube of the carousel planter. This isn't an issue with a water wheel planter or when planting by hand.
- Harden plants off because plants that are lush don't adapt well to the field.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3	9 inches	Normal to deep when plants are tall	Needs fertile conditions. Basil is an aggressive neighboring plant; it's not suitable for companion planting unless pulled up when plants are 6–12 inches tall.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	50	6	¼		Will require thinning
MaterMacc	3	12–20	192 H 0.8	¼	17–18	
Jang	3	4–12	YYJ-24	¼	Front 9/rear 14	

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe in between plants.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge or are still small. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives. These tools effectively eliminate small weeds.

Frost, disease and insect protection

- Basil is very sensitive to cold. Plant when temperatures are mild with no cold nights in the forecast, and harvest before the first frost. For earlier basil, plant through plastic mulch and cover with hoops and floating row covers.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinerne`ma carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Black spots on basil are caused by downy mildew. Some farmers now grow their basil exclusively in high tunnels to prevent this disease. The variety Prospera is relatively resistant to downy mildew. Downy mildew is windborne, so you cannot control it through rotation. Applying an OMRI-listed fungicide isn't recommended, as it will affect the quality of the basil.

Other cultural practices

- Intercropping basil isn't recommended, as it can function as a weed that competes for nutrients with its neighboring crop.
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- After the first frost, work under any harvest remains to avoid pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested basil with a cover crop of oats and peas in September, or with rye and vetch planted at later dates. Adjust accordingly in other regions.

Beans, Snap

Phaseolus vulgaris (*Fabaceae* or legume family)

Soil preparation and general information

- Beans should not follow after other legumes, lettuce, carrots, nightshades, Brassicas or a lush green manure.
- Rotate after cereals (grains like corn and rye, or oats) to avoid soilborne diseases. Beans do quite well when planted through a rolled and crimped rye cover crop. Growing beans in rolled and crimped rye can reduce the incidence of white mold (*Sclerotinia*).
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Total nutrient uptake can reach 170 lbs. of N (with a significant amount coming from N-fixing bacteria), 16 lbs. of P and 80 lbs. of K. Apply compost and other amendments based on the results of a soil test. Too much nitrogen will cause beans to get floppy and fall over.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
40	0–100	0–80	6.2–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- West Virginia green bean variety trial
- Indiana green bean variety trial
- Maxibel, Jade, Isar and Royal Burgundy are favorites for hand picking. The better varieties for machine picking, such as Caprice, contain more fiber, which helps avoid bruising and breaking. Caprice is still tender when harvested a few days late.

Direct seeding information in 30- or 36-inch rows (a tractor with 60- or 72-inch wheel spacing)

- Plant beans when the soil temperature is above 60°.
- Inoculate beans with *Rhizobium leguminosarum bv. Phaseoli* to enhance N fixation, especially in fields where you haven't grown beans before.
- Most rows are 30–36 inches apart because this allows for good airflow. Some growers add the biological control *Trichoderma* (available as RootShield or a similar product) in the planter box to avoid damping off.
- You can also transplant beans using a paper-pot planter, which allows you to get optimum spacing. Start paper pots in the greenhouse. This results in a high rate of germination, and pot spacing of 4 inches (LP303-10) is optimal for easy picking. Plant in the field when the beans are in the cotyledon stage. Completely bury the pot and young plant when planting. They will emerge within 1–2 days. Planting later leads to transplant shock. One tray of LP303-10 can plant one 100-foot row.

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	2	24	Hole #32	½–1		Will need thinning as the optimum spacing is 2–4 inches.
Mater Macc	2	12	24 H 4.5	½–1	22–17	A higher population is used to facilitate a narrow harvest window for machine picking.
Jang	2	6	N-6	½–1	Front 14/rear 9	Difficult to get the correct plant spacing with this seeder.

Seeding time and successions

- Plant seed when the ground is warm and no frost is in the forecast. For the northern United States, successions start in May and end sometime in July.
- Plant each succession when the cotyledons are up on the previous planting. Generally, allow 10–14 days between the first and second succession, and end with intervals of 7 days for a continuous harvest.
- This succession method is more challenging when starting plants in the greenhouse. In this case, plant the second planting 10–14 days after the first one, and then reduce the interval by 1 day until you're on a weekly schedule. This helps you avoid a situation where several successions are ready to harvest at the same time.

Cultivation procedures

- Prepare the seedbed 2 weeks in advance, then again before planting. For machine picking, don't make a raised bed, as a machine harvester needs a flat field.
- Use a finger weeder with torsions in combination with side knives, or alternatively use spring hoes in combination with side knives when weeds are in a white thread stage, or as soon as possible without damaging the crop. Don't use spring hoes when planning to machine harvest, as the machine will pick up soil along with the beans.
- When hand picking, you can use Lilliston rolling cultivators for the last cultivation, or hill with a wheel hoe. Set hillers less aggressively so they hill the plants only slightly.

Frost, disease and insect protection

- Beans are very cold sensitive. Plant after the last frost date or protect your first plantings with row covers. Harvest before the first frost.
- For leafhoppers, use sticky cards to monitor their presence. To control them, use *Beauveria bassiana* at the nymph stage. For severe infestations of leafhoppers use an OMRI-listed pyrethrum product like PyGanic EC 5.0II at the nymph stage; for best results repeat for three 5-day applications. Pyrethrum breaks down quickly when exposed to UV light (it has a half life of 12 hours) and is considered among the shortest-acting insecticides. It's also toxic to bees and other pollinators. For both reasons, apply a pyrethrum-based product in the evening.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- For control of white mold (*Sclerotinia sclenotorium*), plant beans in areas with good airflow and water drainage; use multi-year rotations (at least 3 years); and incorporate the biological control *Coniothyrium minitans* (such as the product Contans). Apply this product to the soil up to 2 months before planting or directly in the planter box. Planting beans after grain crops or mustard also reduces disease pressure.
- Phytophthora blight (*Phytophthora capsici*) is a devastating disease that can be caused by flooding or standing water. There is currently no remedy for this disease. It's recommended to rotate an infected field out of rotation for several years and use biofumigants like mustard to reduce the presence of this pathogen.
- Ozone injury: While ozone injury can dramatically reduce yields, unfortunately there is no remedy. It's mentioned here as it is quite common and often mistaken for a plant disease.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant another short-season vegetable crop like transplanted lettuce, kohlrabi or baby bok choy after early-planted beans.
- For later dates, work under any harvest remains to avoid insect or pathogen build up, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested beans

with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Additional resources

- Organic Production and IPM Guide for Snap Beans

Beets

Beta vulgaris (*Chenopodiaceae* or goosefoot family)

Soil preparation

- Beets should not follow any members of the Chenopod family. Avoid planting beets after potatoes, brussels sprouts, sweet clover or corn.
- Total nutrient uptake is 140 lbs. of N, 14 lbs. of P and 140 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb.of boron per acre to avoid leaf burn.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like beets don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding beets. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
175	0–200	50–400	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Red Ace is a strong performer. Other varieties popular among organic farmers are Merlin, Eagle, Boldor (yellow interior), Bohan, Guardsmark (striped interior) and Chioggia (red and white interior).
- New York variety trial
- Washington State variety trial

Direct seeding information for 5- or 6-foot raised beds

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	50	20	¼–½		
MaterMacc	3	24	144 H 2.5	¼–½	17–19	Use a lower seeding rate for storage beets.

Jang	3	4–12	MJ 24 (small seed) or LJ 12 (large seed)	¼–½	12 hole: front 9/rear 14; 24 hole: front 10/rear 11	

Seeding time and successions

- Plant beets when the soil temperature is at least 45°.
- For weekly availability, seed bunching beets April–July. You can transplant the first succession after sowing 2 seeds per cell in a 128-cell tray, planting at 7–9 inches apart in the row.
- Put plug trays on a wire mesh bench to encourage air pruning.
- In the northern United States, direct-seed storage beets in July for an October–November harvest.
- You can also transplant beets using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Beet seed contains more than 1 seed, and pot spacing of 4 inches (LP303-10) is optimal for easy picking. Plant when the beets have developed their first true leaves. Planting later leads to transplant shock. Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate the first week until roots are established.

Cultivation procedures

- If possible, use stale seedbed practices 1–2 weeks before planting to eradicate weeds. Don't disturb the soil too deeply, as this can bring up new weed seeds. Alternatively, to avoid disturbing the seedbed, use a flame weeder right before seeding. As another alternative, use a silage tarp as described above.
- For both direct seeding and transplants, use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand weed in between plants.
- For the second cultivation, only use sweeps—possibly with torsion weeders—or side knives. To avoid leaf damage, don't use aggressive in-row cultivation tools. Replace the oscillating hoe with sweeps when using a wheel hoe.

Deer, disease and insect protection

- *Cercospora* leaf spot is best controlled by practicing multi-year rotations that don't include any member of the Chenopod family, along with a good control program for weeds like lambsquarters. Other plants, like sweet clover, can be a host of this pathogen. Applying a mixture of a copper product like Cueva and a *Bacillus amyloliquefaciens* product like Double Nickel has been observed to be effective. Other controls to consider are *Bacillus mycoides* isolate J (as in LifeGard); or *Streptomyces Ldicus* (as in Actinovate) with either *Bacillus subtilus* (as in Serenade ASO) or *Reynoutria sachalinensis*, which is an extract made from giant knotweed (as in Regalia).
- Leaf miners can be a serious issue for bunching beets. Use row covers or insect netting to prevent the adult fly from laying its eggs on crops. If row covers or insect netting aren't an option, look on the underside of the leaves for any eggs. In the northern United States there are generally 3 generations of adult flies laying eggs. Once the eggs hatch, or when you see the first signs of damage, apply a spinosyn-based product like Entrust every 5–7 days, not to exceed 3 sprays.
- Deer prefer beet greens over almost any other vegetable. To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape™ at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter, and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.

Other cultural practices

- You can plant beets over a wide range of the season. Early-bunching beets are one of the first crops to

plant, while you shouldn't plant storage beets until July to avoid oversized beets. For this reason, you can use a variety of cover crops before or after a beet crop.

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a short-season vegetable crop like salad mix or arugula after early beets.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested beets with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Bok Choy and Chinese Cabbage

Brassica rapa (*pekinensis* group) (*Brassicaceae* or cabbage family)

Soil preparation

- Chinese cabbage shouldn't follow other members of the Brassica family.
- Average nutrient uptake is 165 lbs. of N, 10 lbs. of P and 208 lbs. of K.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Apply compost and other amendments based on the results of a soil test.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Chinese cabbage planted in late summer does well after a spring seeding of bell beans and forage peas.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Rubicon, Minuet, Bilko

Greenhouse guidelines

- EZ Seeder seeding plate # 16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°–90°	65°–75°	Reduce water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Number of successions

- Spring: Chinese cabbage does poorly during hot and dry weather. Plant Chinese cabbage 2–4 weeks before the last frost date. Depending on your markets, plant each week for a continuous harvest in spring and early summer. In New York, this is limited to 2–3 successions.
- Fall: Chinese cabbage does better as a fall crop. In New York, seeding is resumed in July on a weekly basis until 4–5 weeks before the first frost, for a continuous harvest until November.

Transplanting in 5- or 6-foot beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	12–15 inches	Don't bury the plug; the top of the plug should be level with the soil to avoid leaves touching the soil.	Use a 12- or 15-inch sprocket or planting wheel. Irrigate after planting, and scout for flea beetles. When present, use row covers immediately.

Signs to watch for and what to do

- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant readiness indicators

- Plants are ready when they come easily out of the cell. Plants should generally not be older than 5 weeks.

Cultivation procedures (when transplanted)

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe in between plants.
- For a second cultivation use only sweeps or a hand hoe, and don't hill. Slight hilling or aggressive cultivation can damage the shallow roots and affect growth.

Cultivation procedures (when direct seeded)

- Prepare the seedbed 1–2 weeks in advance, and shallowly stale seedbed before planting, to eradicate weeds if possible. Don't disturb the soil too deeply, as this will bring new weed seeds up to the surface.
- Hand hoe in between plants. Thin when necessary.
- For a second cultivation, use only sweeps or a hand hoe, and don't hill. Slight hilling or aggressive cultivation can damage the shallow roots and affect growth.

Insect protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seeds to hot water treatment. Some organic seed suppliers are hot treating their seeds these days, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstak*i) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.
- To control cabbage leaf miners in a high tunnel, you can release a beneficial wasp (*Diglyphus isaea*), but in the field, only row covers or the use of a spinosyn-based product have proven to be effective.
- Basal stem rot (*Erwinia carotovora*), not to be confused with Rhizoctonia, is caused by insects eating at the basal stem. Damage from cultivation can also help bring this disease to the plant. Aggressive cultivation is not advised in Chinese cabbage production.
- *Rhizoctonia*, or bottom rot, can be an issue with Chinese cabbage and bok choy. Don't allow lower parts of plants to be in contact with the soil, and plant it in a long rotation with other members of the brassica family. Transplanting when soil is at least 55F, reducing irrigation and dipping plants in *Trichoderma harzianum*, as in the product Rootshield, are good preventive measures.

- To avoid Alternaria leaf spot, plant far away or upwind from earlier planted cole crops and avoid overhead irrigation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil has shown some control for a few growers. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce Alternaria as well, by activating the plant's natural defenses against fungal and bacterial diseases.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a short-season, transplanted vegetable crop such as lettuce after early-planted Chinese cabbage.
- For later dates, work under any harvest remains to avoid insect or pathogen build up, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested Chinese cabbage with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Broccoli Rabe

Brassica ruvo (Brassicaceae or cabbage family)

Soil preparation

- Broccoli rabe should not follow after other cole crops.
- Apply compost and other amendments based on the results of a soil test. Incorporate compost and plant broccoli rabe in raised beds.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like broccoli rabe don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding broccoli rabe for good soil-to-seed contact.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	20–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Sessantina Grossa, Spring Raab

Direct seeding information for 5- or 6-foot raised beds

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	30	2–3	¼–½		Plants should be thinned to about 4 inches apart for the best product.
MaterMacc	3	12	192 H 1.0	¼–½	12–17	
Jang	3	6–12	YYJ 12	¼–½	Front 14/rear 10	

Seeding time and number of successions

- In the northern United States, start planting in April and end in May, planting up to 3 successions. When planted in very cold soil, plants bolt too early to have a meaningful harvest. This can also happen with transplants if they experience any transplant shock. Resume planting when flea beetle pressure slows down, or as early as mid-August and ending in September, also in the northern United States. Continue planting beyond this time when located farther south or on the West Coast for a winter harvest.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives. Both methods will eliminate small weeds.

Frost, disease and insect protection

- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - Fall-planted broccoli rabe doesn't need any protection after the third generation of flea beetles, which is around September 1 in the Northeast. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- *Alternaria* leaf spot
    - High pressure of this disease can affect broccoli rabe. You can achieve relatively good control with good rotations. If disease still occurs, use regular applications of the biological control *Bacillus amyloliquefaciens* (as in the product Double Nickel).

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- A short-season, transplanted vegetable like lettuce can follow early broccoli rabe.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested rabe with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Broccoli, Main Crop

Brassica oleracea (italica variety) (Brassicaceae or cabbage family)

Soil preparation and rotation

- Broccoli should not follow other members of the Brassica family for 3 years.
- Total nutrient uptake is 165 lbs. of N, 10 lbs. of P and 210 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsym when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn. Incorporate compost and plant broccoli in raised beds or on flat ground.
- Fall broccoli does well when planted after a spring seeding of oats, forage peas and bell beans at a rate of 45 lbs. of oats, 100 lbs. of peas and 100 lbs. of bell beans per acre. This cover crop can supply all of broccoli's N needs. Mow before the oats start flowering to avoid oats reseeding. Alternatively, remove oats from the seeding mix for easier incorporation.
- You can also plant fall broccoli through a rolled and crimped cover crop of Austrian winter peas. Plant this cover crop in early September at a rate of 200 lbs. to ensure good weed control. In this case, take a soil test in the preceding year and fertilize as needed to provide enough nutrients for both the Austrian winter peas and the vegetable crop. Inoculate seed and reduce N application to enhance N uptake by N-fixing bacteria. To properly kill peas, use a no-till planter (without seed in the box) and slice the cover crop with the coulters of the drill.
- Broccoli does best in cooler climates or during spring and fall in warmer climates. Cooler nighttime temperatures are crucial during head formation and to a much lesser degree in its vegetative stage. Warm nights cause inflorescence (uneven sized flower buds), making it unmarketable.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- Washington State, Oregon, Wisconsin and Minnesota variety trial

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°–85°	60°	Less water	Take plants outside 1 week before planting in the field. Put plug trays on a wire mesh bench to encourage air pruning.

Seeding time and number of successions

- In spring, plant broccoli in a greenhouse 5 weeks before you expect to transplant in the field.
- Plant successions at intervals of 10–14 days starting 4–5 weeks before you have prepared the ground for planting.
- In the northern United States, start planting fall successions at the end of May and go through June. In more southern regions, start later and end later for a harvest that goes into late fall and winter.
- Broccoli needs cool nights during maturation, so succession planting during summer is greatly dependent on location.

Signs to watch for and what to do

- Purpling leaves indicate a phosphorus deficiency in the potting soil; purpling in the field or greenhouse often indicates cold soil. Early use of a greenhouse with heated air can still leave the soil of the cell pack cold due to the cold floor. Address this issue of cold soil possibly causing a P deficiency before you start feeding the plants with a liquid P solution.

Transplanting tips

- Watch transplants during late spring for signs of getting leggy from too much warmth. If this happens, put them outside to harden.
- Transplants should have 4 true leaves and pull easily from their tray. Plants should generally not be older than 4–5 weeks.
- Stocky plants have a higher survival rate in the field. When transplants are lush, remove some leaves to reduce transplant shock.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2–3	8 inches for bunching; 12–14 inches for mainhead	Bury long plants as deep as possible without covering true leaves.	Even when plants slightly wilt, they always come back. Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil.

Cultivation procedures

- Ensure plants are properly rooted before cultivation. Use sweeps (with torsions if possible) in combination with a finger weeder, usually 7–10 days after transplanting or as soon as possible without damaging the plants. Alternatively, use a tine weeder; this works better when you use bare root transplants because tine weeders tend to uproot plugs.
- Hand hoe in between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- If you need a third cultivation, use Lilliston rolling cultivators and hill aggressively without burying the plants.

Insect and disease protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seeds to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.

    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is more than 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.
- Selecting resistant varieties is the best way to control bacterial soft rot.
- Choose tolerant and well-domed varieties to avoid brown bead (a physiological disorder).
- Buttoning up—when a small-framed plant forms a premature small head—usually occurs in the earliest plantings. Some varieties are more tolerant than others.
- To avoid hollow stem, plant closer in the row and choose less susceptible varieties. Hollow stem is another physiological defect caused by high N and K levels in soil.
- To avoid *Alternaria* leaf spot, plant far away or upwind from earlier-planted cole crops and avoid overhead irrigation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil has shown some control for a few growers. Don't mix any mineral oil with adjuvants, as this will cause leaf burn. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce *Alternaria* as well.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Swede midge has become a problem for many growers in the northern United States in recent years. As it is an invasive species, it has no native enemies. Exclusion through row covers or insect netting in combination with rotating more than ½ mile away from last year's crop may provide effective protection.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a cover crop after earlier-planted broccoli. Before planting it, mow the broccoli plants as low as possible with a flail mower. Also, incorporate the residue with a disc to avoid overwintering of insects and diseases.
- Later plantings can be overseeded with a mixture of crimson and red clover, or sweet clover by itself, at a rate of 20 lbs. per acre. This is done right before the last cultivation. Alternatively, plant cereal rye up until a few weeks before harvesting and before the end of October. Take great care to avoid having seeds get caught in the plants.

Additional resources

- Organic Production and IPM Guide for Cole Crops

Broccoli, Early Crop

Brassica oleracea (*italica* variety) (*Brassicaceae* or cabbage family)

Soil preparation

- Cultural practices are similar to Broccoli, Main Crop except that early broccoli is planted on plastic mulch. For super-early broccoli, use infrared transmitting mulch to increase soil temperature.
- Avoid too much plant debris from a previous cash crop or cover crop, as you'll want to lay plastic as early as possible in the growing season.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	12 inches	As deep as possible	Use a 12-inch wheel and add kelp or fish fertilizer to the water as directed by the product label.

Cultivation procedures

- Cover plants with floating row covers.
- Cultivate with a rolling cultivator or spyder between plastic to control weeds.
- If desired, plant a cover crop like oats and peas between plastic, or use weed fabric.
- After harvest, incorporate the cover crop and plant debris to allow for bare fallow.
- Follow with cover crops like rye and vetch.

Brussels Sprouts

Brassica oleracea (*gemmifera* group) (*Brassicaceae* or cabbage family)

Soil preparation

- Brussels sprouts should not follow after other members of the Brassica family. You can plant brussels sprouts after oats and peas, or after oats and hairy vetch. Hairy vetch, which survives over the winter in the northern United States, has the added benefit of reducing disease pressure.
- Average nutrient uptake is 236 lbs. of N, 29 lbs. of P and 235 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn. Incorporate compost and plant brussels sprouts in either raised beds or on flat ground.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New Hampshire variety trial
- Brussels sprout varieties appear to change frequently. Look for disease resistance and uniformity when selecting a variety.

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°–90°	65°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Plants are ready when they pull easily from the cell. Plants should generally not be older than 5 weeks.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	18–24 inches	The plug is buried by soil	Use 18-inch sprocket or 18-inch water wheel; when not available, plant every other hole with a 12-inch wheel.

Transplanting tips

- Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil.

Cultivation procedures

- Ensure plants are properly rooted before cultivation. Use sweeps (with torsions if possible) in combination with a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder; but this works better when you use bare root transplants because tine weeders tend to uproot plugs.
- Hand hoe in between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Move finger weeders away from the crop if they cause damage. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- If a third cultivation is possible before plants start closing in, use Lilliston rolling cultivators and hill aggressively without damaging the plants.

Insect and disease protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is more than 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.
- To avoid *Alternaria* leaf spot, plant far away or upwind from earlier-planted cole crops, and avoid overhead irrigation during sprout formation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil has shown some control for a few growers. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce *Alternaria* by activating the plant's natural defenses against fungal and bacterial diseases.
- Swede midge has become a problem for many growers over the past few years. As it is an invasive species, it has no native enemies. Using row covers or exclusion netting in combination with rotating the crop more than ½ mile away from last year's crop may provide effective protection.

Other cultural practices

- To induce greater yield and uniformity of sprouts, top the plants by removing or pinching the growing point in September, or when the lower sprouts are about ½–¾ inch.
- Slowly remove yellow leaves from lower parts of plants to keep sprouts healthy.
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Brussels sprouts stay in the field until late in the fall and aren't always followed by a cover crop.
- Alternatively, you can overseed rye before the end of August. Take great care to avoid having seeds get caught in the plants

Additional resources

- Organic Production and IPM Guide for Cole Crops

Cabbage, Green and Red

Brassica oleracea (capitata group) (*Brassicaceae* or cabbage family)

Soil preparation

- Cabbage should not follow other members of the Brassica family. Maintain a minimum rotation of 3 years.
- Total nutrient uptake is 165 lbs. of N, 10 lbs. of P and 208 lbs. of K.
- Storage cabbage does well when planted after a spring seeding of oats, forage peas and bell beans at a rate of 45 lbs. of oats, 100 lbs. of peas and 100 lbs. of bell beans per acre. This cover crop can supply all of its N needs. Mow before the oats start flowering to avoid oats reseeding. Alternatively, remove oats from the seeding mix for easier incorporation.
- You can also plant cabbage through a rolled and crimped cover crop of Austrian winter peas. Plant this cover crop in early September at a rate of 200 lbs. to ensure good weed control. In this case, take a soil test in the preceding year and fertilize as needed to provide enough nutrients for both the Austrian winter peas and the vegetable crop. Inoculate seed and reduce N application to enhance N uptake by N-fixing bacteria. To properly kill peas, use a no-till planter (without seed in the box) and slice the cover crop with the coulters of the drill.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- Green main: Storage #4, Rivera, many of the Bejo varieties
- Red main: Integro
- Savoy: Alcosa

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	77°–95°	>60°	Reduce water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Number of successions

- You can seed early cabbage 4–5 weeks before the field is ready for planting. For continuous harvest, continue seeding until June or July. In New York, storage varieties are seeded in the third or fourth week in May and transplanted in early July. Planting varieties that have different days to maturity will spread out the harvest.

Signs to watch for and what to do

- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant readiness indicators

- Transplants are ready when they pull easily from the cell. Generally, plants shouldn't be older than 5 weeks.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3	18 inches	As deep as possible	Use an 18-inch sprocket.
2	14 inches	As deep as possible	Use a 14-inch sprocket.

Transplanting tips

- Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil.

Cultivation procedures

- Ensure plants are properly rooted before cultivation. Use sweeps or side knives (with torsion weeders, if possible) followed by a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder; but this works better when you use bare root transplants because tine weeders tend to uproot plugs.
- Hand hoe between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Move finger weeders away from the crop if they cause damage. Alternatively, use spring hoes in combination with side knives to obtain slight hilling.
- If you require a third cultivation, use Lilliston cultivators and hill aggressively without burying the plants. You can only use this tool when cabbage is planted in 2 rows.

Frost, insect and disease protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
  - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
  - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
  - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*)

product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.

- To avoid *Alternaria* leaf spot, plant far away or upwind from earlier-planted cole crops and avoid overhead irrigation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil has shown some control for a few growers. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce *Alternaria* as well, by activating the plant's natural defenses against fungal and bacterial diseases.
- Swede midge has become a problem for many growers over the past few years. As it is an invasive species, it has no native enemies. Exclusion through row covers and rotation more than ½ mile away from last year's crop may provide effective protection.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- Close plantings of fall cabbage allow for smaller head development. Space storage varieties at 12 inches by 36 inches to allow for a larger head that keeps better in storage. Generally speaking, customers prefer a 3 lb. head, but larger heads keep better in storage.

Double cropping and/or cover cropping

- Plant early cabbage after oats and peas, and summer cabbage after hairy vetch or bell beans.
- You can plant transplanted lettuce after early cabbage. Mow plants as low as possible. Incorporate crop residue.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested cabbage with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Additional resources

- Organic Production and IPM Guide for Cole Crops

Cabbage, Mini

Brassica oleracea (*capitata* group) (*Brassicaceae* or cabbage family)

Soil preparation

- Cultural practices are similar to regular red and green cabbage except that plastic mulch and row covers are often used to allow for early planting of mini cabbage. Plant at least 7 days after laying plastic to allow weeds under the mulch to germinate. When planted right after laying plastic, expect to hand weed the planting holes.
- Avoid having too much plant debris from the previous cash crop or cover crop so that you can lay the plastic as early as possible in the growing season.

Varieties

- Tiara, Arrowhead, Farao
- Red Express

Water wheel planter

Rows	In-row spacing	Planting depth (inches)	Notes
3	12 inches	As deep as possible	Use a 12-inch wheel and add kelp to water as 0.5% solution.

Number of successions

- You can seed mini cabbage 4–5 weeks before the field is ready for planting. For continuous harvest, you can seed every 2 weeks until July. Planting varieties with different days to maturity will spread out the harvest. As cabbage holds up well in the cooler, there's less concern about having several plantings ready to harvest at the same time.

Cultivation procedures

- Cover plants with floating row covers.
- Cultivate with a rolling cultivator or Spyder to control weeds between plastic.
- If desired, plant cover crops like oats and peas between the plastic.
- After harvest, work in plant debris from crops and cover crops to allow for bare fallow.
- Follow with garlic or cover crops like rye and vetch.

Other cultural practices

- To avoid splitting, ensure regular soil moisture.
- Also see the section on green and red cabbage.

Carrots, Full Size

Daucus carota (*sativus* variety) (*Apiaceae* or carrot family)

Soil preparation

- Carrots should not follow other members of the carrot family. They do well after a winter cover crop of oats and peas, or when no cover crop was planted the previous fall. Late-planted carrots do well after an early crop of lettuce or greens.
- Carrots like clean conditions free of weed seeds and fresh organic matter. Avoid planting them after crops that produced seed rain, left the soil compacted or required mulch. While nematodes are a primary cause of forking, raw organic matter can also cause it. Check for a possible plow pan with a penetrometer.
- Total nutrient uptake is 145 lbs. of N, 25 lbs. of P and 150 lbs. of K, which varies greatly based on yield.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- If a plow pan is present, subsoiling before planting will improve root quality and yield. Carrots do well on sandy soils but can thrive on a variety of other soil types as long as the field is well drained and there isn't a plow pan to restrict rooting depth.
- Work in compost and plant carrots in raised beds or ridges. On shallow soils, ridges allow for deeper rooting, which leads to increased yields.
- Carrots require a fine and relatively firm seedbed. If you require deep tillage, prepare the land a few weeks in advance to allow the soil to settle. This also provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
90	0–160	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trials: 2015 and 2016
- New York variety trial of non-orange carrots
- Washington State, Oregon, Wisconsin and Minnesota variety trial
- Michigan variety trial of multiple vegetables, including carrots: 2021 and 2022
- Other varieties popular with organic growers are Bolero, Purple Elite, Rainbow, Dulcinea, Sugarsnax, and Yaya

Direct seeding information for row spacing of 12–18 inches

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	25–50	Plate 5	¼–½		Irrigate before seeding.
MaterMacc	3	20	192 H 0.8	¼–½	22–17	

Jang	3	30	XY-24 or X24; pelleted carrots: MJ-24	¼–½	Front 14/rear 10	

Seeding time and number of successions

- Irrigate your field to full capacity before planting, but take care to use a system that doesn't cause soil crusting. Also, account for any rain in the weather forecast. Soil crusting due to heavy irrigation or rainfall will reduce emergence. Inverted mini sprinklers that water at a low volume can reduce soil crusting. However, it's also important to ensure that germinating seeds don't dry out, as this causes desiccation.
- Plant immediately after flame weeding.
- Spread plantings out over several seedings. For best storage quality in the northern United States, start in April and end by mid-July. In southern states you can start planting the fall crop in early August and harvest later into the fall.
- Carrots germinate best when soil temperatures are above 40° and below 80°. Ideal soil temperatures are typically 55°–65°.

Cultivation procedures

- Flame weed 5 days after seeding or right before carrots emerge. For accurate timing, put a glass plate over a small area of 1 row just after seeding. It's time to flame weed when the seedlings under the glass emerge.
- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Some people will basket weed before seeds have emerged, a practice known as blind cultivation. You can do this successfully if the planter's wheel tracks are still visible when you want to cultivate, because the tractor operator will know where the rows are.
- Hand weed meticulously to avoid having to pull large weeds, as this will also uproot tender carrot seedlings.
- Use torsion weeders with rear-mounted side knives for a second cultivation. After this, hand weed again.
- For a final cultivation, use sweeps with spring hoes or Hak hillers.

Deer, insect and disease protection

- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- To prevent *Alternaria* (leaf blight that also affects the roots by forming black spots on the surface), use tolerant varieties and expose seed to hot water treatment. Good short-season varieties (like some of the Chantenay types) that can be seeded late are another remedy. Timing irrigation by only water during the day helps limit the spores' ability to incubate.
- To prevent carrot fly infestations: In the Northeast, planting after the end of May can prevent the first generation of egg-laying flies. Harvesting an early planting by mid-June will get carrots out before the larvae enter the taproot or grow large enough to be noticed. Harvest early plantings in blocks and be sure to harvest the crop completely so that the area doesn't produce second-generation flies. Adjust these dates according to your location.
- Covering with insect netting or a floating row cover is the most effective method to prevent a carrot fly infestation. However, floating row covers will increase the temperature underneath, which isn't always desired.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a short-season vegetable crop like salad mix or arugula after early-planted carrots.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested carrots with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.
- Storage carrots are generally not overseeded or followed by a cover crop unless you harvest by the end of October. Interseeding with rye or vetch isn't successful, as digging up the carrots disturbs the root system of the cover crop.

Additional resources

- The Midwest Veg Guide 2024 provides some information on what type of carrots do best in different soil types commonly found across the Midwest.
- Organic production and IPM guide for carrots

Carrots, Baby or Bunching

Daucus carota (sativus variety) (Apiaceae or carrot family)

For additional production information, see the entry Carrots, Full Size.

Varieties

- Yaya, Nelson or Mokum for baby carrots
- Naval for longer carrots

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	25–50	5	¼–½		Irrigate before and after seeding.
Sutton Jr.	5	32	8	¼–½		Use a speed of 0.8 mph.
Jang	5	32	X-24	¼–½	Front 14/rear 9	

Number of successions

- Plant as soon as the soil warms up, approximately in April. Soil temperatures should be above 40°, and ideally 55°–65° for the best germination rate.
- For a continuous supply, plant carrots after cotyledons have emerged.

Cultivation procedures

- Only choose your cleanest ground for early seeding of baby carrots.
- Alternatively, prepare ground for the first planting of carrots in the fall and cover with a silage tarp.
- Otherwise, follow all other cultural practices as in Carrots, Full Size.

Cauliflower

Brassica oleracea (*botrytis* group) (*Brassicaceae* or cabbage family)

Soil preparation

- Don't follow cauliflower after other cole crops.
- Total nutrient uptake is 165 lbs. of N, 10 lbs. of P and 208 lbs. of K.
- Plant early cauliflower after a cover crop of oats and field peas.
- Summer-planted cauliflower does well when planted after a spring seeding of oats, forage peas and bell beans at a rate of 45 lbs. of oats, 100 lbs. of peas and 100 lbs. of bell beans per acre. This cover crop can supply all of cauliflower's N needs. Mow before the oats start flowering to avoid oats reseeding. Alternatively, remove oats from the seeding mix for easier incorporation.
- You can also plant fall cauliflower through a rolled and crimped cover crop of Austrian winter peas. Plant this cover crop in early September at a rate of 200 lbs. to ensure good weed control. In this case, take a soil test in the preceding year and fertilize as needed to provide enough nutrients for both the Austrian winter peas and the vegetable crop. Inoculate seed and reduce N application to enhance N uptake by N-fixing bacteria. To properly kill peas, use a no-till planter (without seed in the box) and slice the cover crop with the coulters of the drill.
- Incorporate compost or a cover crop of oats and peas, and plant cauliflower in raised beds or on flat ground.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb.of boron per acre to avoid leaf burn.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- Varieties popular with organic growers are Panther (green), Quasar, Cassius and Skywalker

Greenhouse guidelines

- EZ Seeder seeding plate #1

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°–90°	>60°	Reduce water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in field.

Seeding time and number of successions

- For spring harvest, seed cauliflower in a greenhouse 5 weeks before you can transplant in the field. You can spread out the harvest with multiple plantings or by using varieties with different days to maturity.
- For fall harvest, choose multiple varieties with different days to maturity to stagger the harvest. Follow that with a few more plantings of the variety with the longest days to maturity to finish off the season. In the northern United States, fall-harvested cauliflower is seeded in late May through June, and it is transplanted in July.

Signs to watch for and what to do

- Watch that plant starts don't start to get leggy from too much warmth; put them outside if you notice this happening.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplants are ready when they pull out of their cells easily, and they should not be older than 5 weeks. Stunted plants don't form large heads. Transplanting after 5 weeks can lead to plants being rootbound, which increases the risk of transplant shock.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	24 inches	As deep as possible	Use a 24-inch sprocket or water wheel. Water after planting.

Transplanting tips

- Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil. Ensure plants are properly rooted before cultivation.
- Plant as deep as the plant allows without burying any leaves.

Cultivation procedures

- Ensure plants are properly rooted before cultivation.
- Use sweeps (with torsions if possible) followed by a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder; but this works better when you use bare root transplants because tine weeders tend to uproot plugs.
- Hand hoe in between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- If a third cultivation is necessary, use Lilliston rolling cultivators and hill aggressively without burying the plants.

Frost, insect and disease protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis*

kurstaki, or spread a baited product containing spinosyn, like Seduce, around the plants.

- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is more than per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.
- To avoid *Alternaria* leaf spot, plant far away or upwind from earlier-planted cole crops, and avoid overhead irrigation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil have shown some control for a few growers. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce *Alternaria* as well by activating the plant's natural defenses against fungal and bacterial diseases.
- Swede midge has become a problem for many growers over the past few years. As it is an invasive species, it has no native enemies. Exclusion through row covers and rotation more than ½ mile away from last year's crop may provide effective protection.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- As the cauliflower matures, cover the white part with the outer leaves to prevent the curds from yellowing. Inspect the crop 3 times a week and cover the emerging heads (the moment when the small white heads are just visible through the leaves) by cracking a few leaves and bending them over so the heads are no longer exposed to direct sunlight. By the time the leaves wither, the head should be at full size. Another method is to bundle the outer leaves with a large rubber band. Use a different color rubber band for each inspection day, which allows harvesters to know how long a plant has been covered.

Double cropping and/or cover cropping

- If possible, mow plants as low as possible with a flail mower. Incorporate crop residue with a disc, and plant a cover crop.
- If it's too late to establish a cover crop, leave cauliflower plants in the field after harvest. Cauliflower plants are better at holding soil in place over the winter than a poorly established cover crop. Alternatively, you can overseed rye a few weeks before harvesting, but it needs to be done before the end of October. Be careful not to get seeds caught in the plants. Never broadcast rye after the curds have started to develop.

Additional resources

- Organic Production and IPM Guide for Cole Crops

Celeriac

Apium graveolens (rapaceum variety) (Apiaceae or carrot family)

Soil preparation

- Celeriac should not follow other members of the carrot family, potatoes, cereals or cucurbits due to weed problems.
- Total nutrient uptake is 105 lbs. of N, 16 lbs. of P and 160 lbs. of K.
- Apply compost and other amendments based on the results of a soil test. Incorporate compost based on soil test results, and plant celeriac in raised beds.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
180	0–200	60–300	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Diamant, Brilliant

Seeding time and number of successions

- 1 planting only, 10–12 weeks before transplanting in the field.
- To avoid bolting, make sure the celeriac isn't exposed to cold temperatures (45°) for more than 10 days. Keep the greenhouse at a minimum of 55°.

Greenhouse guidelines

- EZ Seeder seeding plate #13

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
288	70°–75°	60°–70°	Reduce water Avoid low temps	Put plug trays on a wire mesh bench to encourage air pruning. Keep the greenhouse at a minimum nighttime temperature of 55°.

Transplant readiness indicators

- When the plants have at least 2 true leaves, transplant them to 72-, 98- or 128-cell trays.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3	12 inches	Make sure the crown isn't buried, since that will stop the plant from growing	Use a 12-inch sprocket or water wheel. Plant on your best ground.

Transplant tips

- As celeriac doesn't provide a lot of shading, the crop tends to get weedy. You can transplant it in plastic mulch for better weed control. This also provides for much better water management.
- Harden plants off outside; plants that are lush don't perform well in the field.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.
- For a second pass, use side knives only, or use a wheel hoe again. Hand hoe or hand weed again.
- Because celeriac doesn't provide much shade and weeds will continue to be a problem throughout the season, keep the crop clean by frequently hand hoeing between plants.

Other cultural practices

- Celeriac is a finicky crop, as many organic growers experience difficulty supplying sufficient N and water to the crop during the growing season. You get the best results by side-dressing with an OMRI-listed fertilizer.
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- As celeriac is harvested in November, it's often too late to establish a cover crop or follow it with another cash crop.

Celery

Apium graveolens (*Apiaceae* or carrot family)

Soil preparation

- Celery should not follow other members of the carrot family.
- Total nutrient uptake is 195 lbs. of N, 50 lbs. of P and up to 435 lbs. of K.
- Incorporate compost and plant celery in raised beds.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
180	0–200	60–300	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Ventura, Kelvin, Tango

Greenhouse guidelines

- EZ Seeder seeding plate #13

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
288	70°–75°	60°–70°	Reduce water; no low temps	Put plug trays on a wire mesh bench to encourage air pruning. Exposure below 55° for 10 days or more causes bolting.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- When there are 2 true leaves, transplant to 72-cell trays.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	6–8 inches	Can be planted deeper than celeriac	Plant on your best ground.

Cultivation procedures

- Basket weed 7–10 days after transplanting, when weeds are still in the white thread stage and celery plants are established.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Move finger weeders away from the crop if they cause damage. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- Hand hoe or hand weed between plants.

Insect and disease protection

- Common problems include a lack of nitrogen, calcium and boron. These can cause physiological disorders like hollow heart (not to be confused with celery anthracnose, as hollow heart is dry).
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Celery anthracnose is an emerging problem for celery growers in the Northeast. Its hosts include strawberries, garlic (including discarded garlic scapes) and fennel, so avoid rotating with these crops. It's also hosted by weeds like red-rooted amaranth and lambsquarters. Avoid overhead irrigation.
- Aster yellows is the most common issue affecting celery (and many other vegetable crops).
- Leaf hoppers transmit both celery anthracnose and aster yellows, so monitor for them. Place yellow sticky cards at plant height and check them at least twice a week.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- Celery, like celeriac, needs fertile ground with plenty of moisture and organic matter to do well.

Double cropping and/or cover cropping

- Work under any harvest remains to avoid insect or pathogen build up, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested celery with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Chard, Swiss

Beta vulgaris (*cicla* variety) (*Chenopodiaceae* or goosefoot family)

Soil preparation

- Swiss chard should not follow after spinach or beets, but later plantings do very well after early peas or lettuce.
- Total nutrient uptake is 105 lbs. of N, 16 lbs. of P and 160 lbs. of K.
- Apply compost and other amendments based on the results of a soil test. Incorporate compost and plant chard in raised beds.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like Swiss chard don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- When direct seeding Swiss chard, create a fine and firm seedbed chard to facilitate good seed-to-soil contact.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial
- Bright Lights has become a standard on many vegetable farms, but Golden Sunrise, Magenta Sunset, Fordhook Giant, Rhubarb Supreme and Oriole are common as well.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3 or 5	50	22	Depth 2–3		
Sutton Jr.	5–9	35	24	¼–½		0.8 mph (when harvested for braising mix)
Jang	3 or 5	6–24	LJ 12	¼–½	See notes	The sprocket setting depends on how you harvest the crop. Use front 11/rear 13 for individual stems, or front 14/rear 9 for loose leaf.

Greenhouse guidelines

- EZ Seeder seeding plate #9

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°–90°	65°–75°	Reduce water	2–3 seeds per cell. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Number of successions

- For single harvest, plant each succession when the cotyledons are up on the previous planting. Generally, allow 10–14 days between the first and second succession, and end with intervals of 7 days for continuous harvest.
- When harvesting multiple times from the same plants, reduce the number of successions accordingly.

Signs to watch for and what to do

- Watch that plants don't start to get leggy from too much warmth and lack of light.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant readiness indicators

- Plants should come easily out of their cells. Generally plants shouldn't be older than 4 weeks.

Transplant tips

- You can also transplant chard using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Chard seed contains more than 1 seed, and pot spacing of 6 inches (LP303-15) is optimal for easy picking. Plant when Swiss chard has developed its first true leaves. Planting later leads to transplant shock. Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate the first week until roots are established.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3	5 inches	Don't bury the plug; the top of the plug should be level with the soil to avoid leaves touching the soil.	Tends to have transplant shock; plant in late afternoon to avoid burning plants.

Cultivation procedures

- Basket weed 7–10 days after planting. Use a basket weeder or wheel hoe when weeds are in the white thread stage. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives. These tools effectively eliminate small weeds.

Frost, disease and insect protection

- Leaf miners can be a serious issue for Swiss chard. Use row covers or insect netting to prevent the adult fly from laying its eggs on the crop. If row covers or insect netting aren't options, place yellow sticky cards at plant height and check them at least twice a week. Otherwise, look on the underside of the leaves for any eggs. In the northern United States, there are generally 3 generations of adult flies laying eggs. Once the eggs hatch, or when you see the first signs of damage, apply a spinosyn-based product like Entrust every

5–7 days, not to exceed 3 sprays.

- *Cercospora* leaf spot is best controlled by practicing multi-year rotations that don't include any member of the Chenopod family, along with a good program to control weeds like lambsquarters. Other plants, like sweet clover, can be a host of this pathogen. Applying *Bacillus amyloliquefaciens*, as in the product Double Nickel, has been observed to have efficacy. Application of *Reynoutria sachalinensis*, which is an extract made from giant knotweed (as in Regalia), has shown some efficacy as a preventive schedule.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Don't plant another cash crop after early chard, as its roots will regrow and act as a weed. Establish a cover crop after working the ground with a disc and harrow.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested chard with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Cilantro

Eryngium foedum (*Apiaceae* or carrot family)

Soil preparation

- Cilantro should not follow after other members of the carrot family.
- Late cilantro does well after early lettuce, greens or peas.
- Apply compost and other amendments based on the results of a soil test. Incorporate compost and create raised beds.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like cilantro don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding cilantro to facilitate good seed-to-soil contact. When preparing a seedbed a few weeks in advance, shallow cultivation or flame weeding right before seeding will reduce weed pressure.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date (depending on the time of year). This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
90	0–160	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	50	22	Depth 3		
Sutton Jr.	9	50	24	½		0.7 mph
Jang	5	12–24	MJ 24	½	Front 14/rear 10	

Transplant tips

- You can also transplant cilantro using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Use a pot spacing of 2 inches (CP303), which is the closest match but a bit wide for cilantro. Plant when the cilantro has developed its first true leaves. Planting later leads to transplant shock. Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate the first week until roots are established.

Seeding time and number of successions

- Irrigate your field to full capacity before planting, but take care to use a system that doesn't cause soil crusting. Also, account for any rain in the weather forecast. Soil crusting due to heavy irrigation or rainfall will reduce emergence. Inverted mini sprinklers that water at a low volume can reduce soil crusting. However, it's also important to ensure that germinating seeds don't dry out, as this causes desiccation.

- Spread plantings out over several seedings, starting in May and ending by mid-August in the northern United States. Cilantro germinates best when soil temperatures are 55°–68°. Cilantro is considered a cool-season crop and will bolt when temperatures exceed 85°. Avoid summer plantings in regions with hot summers.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant another short-season vegetable crop like lettuce, spinach, salad mix or arugula after early plantings of cilantro.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested cilantro with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Corn, Sweet

Zea mays (*Poaceae* or grass family)

Soil preparation

- Corn should not follow corn, other grains or cucurbits.
- Total nutrient uptake is 155 lbs. of N, 20 lbs. of P and 105 lbs. of K.
- Corn does well after a leguminous green manure like sweet clover. But note that early plantings will not be able to depend on the N provided by clover. Nitrogen-fixing bacteria become active when soil is sufficiently warm (over 48°).
- Apply compost and other amendments based on the results of a soil test. Incorporate compost and plant corn in raised beds or on flat ground.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Sweet corn can be planted through a rolled and crimped cover crop like vetch or Austrian winter peas. To ensure good weed control, plant the vetch in early September of the previous year at a rate of 40 lbs. per acre, or the peas at a rate of 200 lbs. per acre. Fertilize to provide nutrients for both the vetch and the sweet corn at that time (based on the results of a soil test). To properly kill vetch or Austrian winter peas, use a no-till planter (without seed in the box) and slice the over crop with the coulters of the drill. Additional N for corn will be based on the results of a pre-sidedress nitrate test (PSNT).

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
140	0–160	0–160	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Wisconsin variety trial
- New York variety trial
- Sweet corn varieties are listed as either standard sugary (su), sugary enhanced (se), shrunken-2 or supersweet (sh2), augmented supersweet (shA), or synergistic (syn). Augmented supersweet varieties with good flavor include Mirai types and the XtraTender series. Unfortunately, birds love these too. There are many good organic corn varieties on the market, including Double Standard, Allure and Enchanted.
- Robust is a good variety for popcorn.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	2	3	24 H 4.5	1	22-17	Soil temperature should be at least 65° for se and sh2 untreated varieties.
Jang	2	6	A6 AA6, or N6		Front 13/rear 10	With shrunken seed, it's difficult to find the right adjustment for effective singulation.

- You can also use an Earthway seeder for direct seeding. Use the corn seed plate or smaller when planting shrunken seed.
- Direct seeding within organic guidelines often results in poor stands. Poor stands cause poor weed control and poor yields. Therefore, many organic growers prefer to transplant sweet corn.

Greenhouse guidelines

- Seed corn in cell-pack trays 2 weeks before transplanting. To increase transplanting speed, plant 2 seeds per cell. This allows you to plant 2 plants in 1 cell at 14–16 inches apart. The objective is to have a population of 24,000 plants to the acre for irrigated sweet corn. Not every cell will have 2 plants. Adjust your in-row spacing based on your wheel track spacing (60 or 72 inches). Adjust your numbers downward when planting non-irrigated sweet corn.
- Place the trays on wire benches to achieve proper air pruning. Sweet corn has a very aggressive root system.
- Alternatively, use a paper-pot system using a 6-inch spacing with 1 seed per pot.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	70°–95°	65°	Withhold water	Plant 2 seeds per cell. Put plug trays on a wire mesh bench to encourage air pruning. Move outside 3 days before transplanting.

Number of successions

- Seed the first sweet corn 2 weeks before it can be planted in the field. This date can vary depending on whether you plan to provide some frost protection. Medium-weight row covers (0.56–0.9 oz per square yard) can protect crops against 26°–28° nighttime temperatures.
- Be aware that protecting sweet corn with a row cover will also decrease the days to maturity, so you'll need to cover the next succession as well or seed it less than a week after the first planting.
- If you're not using row covers, plant the second succession 2 weeks after the first planting. Reduce seeding time by 1–2 days until you're on a weekly schedule.
- In the northern United States, corn earworm becomes too difficult to control organically, so the last seeding date for 75-day corn falls around the end of July.

Signs to watch for and what to do

- Harden plants outside for a few days. Plants that are lush don't perform well in the field.
- Don't grow tall transplants.

Transplanting tips

- Transplant as soon as plugs pull well and stay together. If roots are tangled to the bottom of the tray (a result of poor air pruning) you'll need to cut them or pull them out straight so that they don't interfere with planting.
- When using paper pots, transplant in the field before seeds have germinated, or immediately after. Once the corn is up, its root system starts branching on the bottom of the paper-pot tray. Air pruning isn't possible with paper pots. The other disadvantage of planting corn using a paper-pot system is when birds try to dig up the young plants: They will pull not just 1 plant at a time, but a chain of paper pots.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	14–16 inches	As deep as possible	Use this in-row distance when seeding 2 seeds per cell. Transplanting works well with a carousel transplanter; planting by hand or using a water-wheel planter might not be economically viable.

Planting procedures

- Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil. Ensure plants are properly rooted before cultivation.
- Isolate your supersweet corn varieties from non-supersweet varieties by at least 300 feet to avoid cross pollination. Cross pollination will cause tough, starchy kernels in both types. If this isn't possible, make sure

your other varieties have a day-to-maturity difference or planting date difference of at least 12 days from the supersweet varieties.
- For corn in general, plant in blocks of at least 4 rows to ensure good pollination.

Cultivation procedures
- Your first pass will be different based on whether you're transplanting or direct seeding the corn.
    - Transplanting: Use side knives with a torsion weeder (if possible) in combination with a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder, but be careful to avoid uprooting plugs.
    - Direct seeding: Use a tine weeder when weeds are in the white thread stage. You can use the tine weeder before the corn has emerged as it forms a strong root system before it spikes.
- Hand hoe between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass when new weeds emerge. Move finger weeders away from the crop if they cause damage. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- If a third cultivation is needed or possible, use Lilliston rolling cultivators and hill aggressively without burying the plants.

Frost, insect and nuisance animal protection
- Corn rootworm is an issue when corn is direct seeded. Transplanting is a good remedy.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- European corn borers (ECB) can be controlled with a spinosyn-based product, like Entrust, or with *Bacillus thuringiensis*, as in *Bt kurstaki*. Spraying is cost effective when you meet a threshold of finding more than 10 moths per day in a pheromone trap. Other means to observe ECB presence are small pin holes on the leaves—referred to as shot hole injury, these holes tend to line up perfectly horizontally—or broken off immature tassels. These last 2 methods are unfortunately too late to obtain good control, as the first application should be when corn is in the whorl stage. Repeat application 3–5 days later to ensure coverage of all emerging tassels. Use high pressure (150 psi) to provide good penetration. As spinosyn-based products kill many beneficial insects, including bees, spray it only very early in the morning or later at night when insects are less active.
- Alternatively, use releases of *Trichogramma ostrinea*, a parasitic wasp. You can get excellent control of ECB when their pressure is low. The key is to introduce wasps to the field when the corn is knee high. Releasing 30,000 eggs per acre for about 3 weeks has been proven to yield better results.
- For corn earworm, use a product containing the nuclear polyhedrosis virus, as in the biological control product Gemstar LC, at the recommended rate. Alternatively, apply Gemstar or *Bt kurstaki* to individual ears using a Zealater applicator. Adding an attractant like molasses and milk will increase the effect.
- Gemstar provides some control for fall armyworm, but apply *Bt kurstaki* or Entrustin case of an outbreak.
- Put up an electric deer fence to prevent them from eating the silk. Silk damage results in an unmarketable ear, as each piece of silk will create 1 kernel. To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- For raccoon control, use a separate electric fence when corn has visible ears. To get effective control, only use a high-voltage fence charger suitable for nylon woven wire.
- For bird control you can use an electric sound deterrent system, such as Bird Gard, which produces the distress calls of certain birds and the watch calls of predators. In extreme cases you can use a propane-fired bird cannon that produces a blast at set intervals. Neither is effective long term as birds get used to the sound. Balloons can be effective but need to be taken down each time you use the boom

sprayer. Some people have effectively used lasers designed for bird control, which has become more cost competitive over the years.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- After harvest, mow and incorporate corn to reduce future ECB infestations. No-till planting of cover crops isn't advisable as ECB will overwinter in the corn stalks. If you want to lay plastic mulch during the following season, make sure you carefully shred the corn stalks before planting a cover crop. Sharp corn stalks break down slowly and can poke holes through the plastic mulch.
- Corn that was planted later can be followed by rye and vetch.

Additional resources

- Organic Insect Management in Sweet Corn

Cucumbers, Field

Cucumis sativus (*Cucurbitaceae* or cucumber family)

Soil preparation

- Cucumbers should not follow other cucurbits or nightshades, but they do follow well after cole crops, sweet corn and some leguminous green manures.
- Where *phytophthora* (*phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost and plant cucumbers in high raised beds covered with plastic mulch. Infrared transmitting (IRT) plastic mulch can help raise the soil temperature for the earliest plantings.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Virginia variety trial
- Select varieties with broad disease resistance.
- If you want to maintain an insect cover until harvest, choose a parthenocarpic variety, or one that will set fruit without pollination. Monoecious varieties produce both male and female flowers, while gynoecious varieties produce only female flowers. If a variety is gynoecious only, you'll need cross pollination from another variety. This other variety is often mixed with the gynoecious variety in the seed packet.
- Open pollinated and organic favorites include Marketmore 76, 86 and the downy-mildew-resistant varieties 97 or 420 (if available).
- Corinto is both gynoecious and parthenocarpic, meaning it will produce seedless fruit.
- Gateway #4777 (gynoecious) offers a high level of disease resistance.
- Eureka and H-19 varieties are good for pickling.

Greenhouse guidelines

- EZ Seeder seeding plate #5
- Use a 1020 tray with 24 pots for more light, which results in stockier plants. When using a 38-pot tray, make sure you transplant before they get leggy.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	80°–95°	>70° day >60° night	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Space cucumber flats like checkers when plants get leggy to obtain more light.

Seeding time and number of successions

- Start transplants 3–4 weeks before you're ready to set them out in the field or in a high tunnel. Make sure the soil is sufficiently warm; it should be at least 60°. Temperatures below this will stunt the plant.
- Plant every 2–3 weeks until July for continued harvest through the season. In the northern United States the last seeding will be some time in July.

Direct seeding information

- Seeding directly into bare soil or through plastic mulch works very well after the soil has sufficiently warmed up. It's important to use row covers or insect netting to protect young seedlings against striped cucumber beetles.

Transplant readiness indicators

- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they don't, roots will be damaged and the plants will have a higher fatality rate.
- To reduce elongated growth in seedlings, brush plants with a broom at least once a week to get stocky seedlings. Dr. Joyce Latimer of Virginia Cooperative Extension found that this type of mechanical stimulation is an effective way to prevent excessive stem elongation (stretching). Brush across the top of the canopy in long gentle strokes with a broom, preferably one that is unpainted because leaves won't stick to it. Run the broom about ½–1 inch below the top of the canopy to gently lean the plants over. Begin treating cucumbers as soon as the cotyledons open, and brush for the next 5 days. It keeps the plant stem about 25% shorter. More treatment than that can damage the leaves. If you see damage, it's too much! Brush when the foliage is dry but the plants aren't wilted. Mostly, this will be before watering in the morning.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant tips

- Lay plastic mulch at least a week before planting to allow the soil to warm and weed seeds to germinate. Planting on the same day you lay the plastic will cause weed pressure in the planting hole.
- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.
- To help resist cucumber beetle damage, dissolve Kaolin clay (Surround) in plenty of water and drench the complete tray in the solution before transplanting.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
1	12–18 inches	Cover the complete root ball	Take great care to make sure the root ball stays attached to the plant, as cucumbers do not like to be transplanted. Keep a walking break in the plantings.

Cultivation procedures (without plasticulture)

- Cucumbers are commonly planted in plastic mulch but will also do well on bare ground.
- If growing cucumbers in the traditional bed system on bare ground, you can use your regular cultivation toolbar with side knives, set up for 1 row cultivation. Don't use any finger weeders—precision cultivation can easily damage cucurbits. Keep some distance from the plant to avoid crop damage. Hand hoe between plants.

Cultivation procedures (with plasticulture)

- When using plasticulture, plant at least a week after laying the plastic mulch to allow weeds to germinate under the plastic. Use IRT plastic to warm the soil earlier in the season.
- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder to control weeds. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K

and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Plant early plantings downwind from later varieties, as both powdery and downy mildew are windborne.
- For your earliest plantings, use floating row covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If frost protection or providing a warm environment isn't necessary, use insect covers to provide protection against beetles.
- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis* (as in CEASE), and potassium bicarbonate (as in MilStop SP). Sulfur causes phytotoxicity in cucumbers, so be careful when applying sulfur in any form to control powdery mildew. A full list of OMRI-listed control products on powdery mildew is available from CALS.
- Downy mildew can be somewhat controlled with the biological control *Pseudomonas aeruginosa*, available as a product as Zonix. Also, consider using tolerant or resistant varieties. A full list of OMRI-listed control products is available from CALS.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Remove all plastic mulch and drip tape.
- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested cucumbers with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Additional resources

- *Managing Cucurbit Downy Mildew on Organic Farms*
- Organic Production and IPM Guide for Cucumbers and Squash

Cucumbers, High Tunnel

Cucumis sativus (*Cucurbitaceae* or cucumber family)

For additional production information, see the entry Cucumbers, Field.

Soil preparation

- Apply compost and other amendments based on the results of a soil test, and plant cucumbers in high raised beds.
- Early crops must be planted in warm soil. You can accomplish this by either preparing a hotbed (a heated cold frame) or by laying infrared transmitting (IRT) plastic a few weeks before planting and closing up the greenhouse to trap the heat.
- A soil test will determine if additional K is needed. Apply all additional N and K that's needed through a drip line.

Varieties

- Pennsylvania high-tunnel variety trial
- Select varieties with broad disease resistance and suitability for greenhouse production. Most greenhouse varieties don't require pollination (they are parthenocarpic) and result in seedless cucumbers.
- Katrina is a favorite of many growers during hot summer conditions.
- Corinto, Poniente and Socrates are good organic varieties.

Greenhouse guidelines

- EZ Seeder seeding plate #5

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	80°–95°	> 70° daytime > 60° nighttime	Withhold water	Space cucumber flats like checkers when the plants get too leggy. Put plug trays on a wire mesh bench to encourage air pruning.

Number of successions

- Due to the high investment of time and inputs this crop requires, growers try to sustain their trellised cucumbers throughout the season.
- Otherwise, you can have 1 very early crop and 1 very late crop to avoid low market prices at the height of the season.

Greenhouse guidelines

- Grafting cucumbers is a way to improve crop vigor and yield while providing disease resistance. It's a common practice for organic greenhouse producers in the Netherlands. Grafted plants are usually grown in 3-inch pots.

Transplant readiness indicators

- For non-grafted plants, transplant from a 24- or 38-cell tray when the plants have formed 2 true leaves.
- Transplant in the high tunnel when plants have enough of a root ball to hold the pot together. When they don't, they'll get damaged and have a high fatality rate.

Disease and insect protection

- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis* (as in CEASE), and potassium bicarbonate (as in MilStop). Sulfur causes phytotoxicity in cucumbers, so be careful when applying sulfur in any form to control powdery mildew. A full list of OMRI-listed control products on powdery mildew is available from CALS. Good sanitation is also important to slow the spread of powdery

mildew. Remove the first occurrences from the high tunnel and harvest the infected areas of the high tunnel last.

- Scout weekly for spider mites. You can achieve control with beneficial insects and trap crops. Start the season off using potted green beans around the interior perimeters to serve as traps. When these plants show spider mites, release the beneficials. At the same time, support predators by intercropping with nectar and refuge plants (such as alyssum or marigolds) at row ends and in a few other spots inside the structure.
- Scout weekly for thrips. An organic control option for thrips is a spinosyn-based product (such as Entrust) approved for tunnel application. Biocontrol options exist but must be introduced early and repeatedly to keep the thrips population in check. They aren't effective once the pest population is well established. Both western flower thrips and onion thrips can infest and significantly damage cucumbers.
- Where *phytophthora* blight (*phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- Greenhouse cucumbers need a significant amount of water and nutrients to thrive. Plant tissue testing is highly recommended. Adjust soil nutrient levels with a fertilizer injector when using drip irrigation.
- Greenhouse cucumbers need trellising since they are a vine crop. To trellis them:
    - Select either the single- or double-leader method, whereby the stem is trellised on twine hung from a support in the form of a suspended wire or conduit.
    - The vines are nudged to grow clockwise around the twine towards the support wire and are then allowed to drape down over the wire or conduit and grow toward the ground.
- To allow for vegetative growth, some growers remove all fruit until the leader (or double leader) reaches the top of the wire, so that no flowers are allowed to form until the sixth or seventh leaf.

Additional resources

- Alabama Extension Greenhouse Cucumber Production

Daikon

Raphanus sativus (*Brassicaceae* or cabbage family)

Soil preparation

- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the rate recommended by your soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Incorporate compost and plant daikon in raised beds.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like daikon radishes don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding daikon to facilitate good seed-to-soil contact.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
50	0–125	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Summer Cross no. 3, Miyashige

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	2	3	24 H 2.5	½	22 – 17	
Jang	2	3	X12		Front 10/rear 14	

Number of successions

- One planting in the spring as soon as land is prepared. Daikon won't thrive in hot weather.
- Plant weekly successions from July 15 until September 1 in the northern United States for a continued harvest from September through November.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- For a second cultivation use a finger weeder or spring hoes in combination with side knives. These tools effectively eliminate small weeds.
- Remove finger weeders and spring hoes from your cultivation setup if they cause any crop damage, and cultivate with side knives only.
- Remove surviving weeds by hand.

Frost, disease and insect protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds,so check with them before applying your own treatment, as double treatment can affect germination.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Keep covered until harvest, if possible. Maggots appear in 3–4 generations in the Northeast, starting in early spring, and can do extensive damage to daikon roots.
- Check the soil for wireworms, as a high population can cause roots to become unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Applications of *Beauveria bassiana* have also shown promising results.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - Flea beetles emerge over 2–3 generations per season. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- To avoid future generations of flea beetles, spray beneficial nematodes on infected land or in hedgerows where they overwinter.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a short-season vegetable crop like salad mix or arugula after early-planted daikon.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested daikon with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Dandelion Greens

Cichorium intybus (*Asteraceae* or *Compositae* family)

Soil preparation

- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost, and plant dandelions in raised beds.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like dandelions don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding dandelions. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Dandelion is actually a chicory, favored by traditional Italian customers.
- Popular varieties are Catalogna Special and Red Rib

Greenhouse guidelines

- EZ Seeder seeding plate #9

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	56°–85°	60°–75°	Withhold water	Sow 3 seeds to a cell. Remove from the greenhouse 5 days before planting. Put plug trays on a wire mesh bench to encourage air pruning.

Carousel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
3	5 inches	Normal; do not bury the plant.	

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	3	12–15	96 H 0.8	¼–½	22-17	For bunching
Sutton Jr.	9	50	8	¼–½		1 mph for salad or braising greens
Jang	3	12	F 24	¼–½	Front 14/rear 10	

Transplant tips

- You can also transplant dandelions using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Use 2-inch pot spacing (CP303) for optimal spacing. Plant when the dandelion has developed its first true leaves. Planting later leads to transplant shock. Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate the first week until roots are established.

Number of successions

- Plant each succession when the cotyledons are up on the previous planting. Generally, allow 10–14 days between the first and second succession, and end with intervals of 7 days for continuous harvest.
- When harvesting multiple times from the same plants, reduce the number of successions accordingly.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand weed or hoe between plants.
- You can harvest dandelions twice if you keep the crop clear of weeds. Use side knives or sweeps only to eliminate weeds.

Other cultural practices

- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant another short-season vegetable crop like arugula or turnips after early-planted dandelions.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested dandelions with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Eggplants

Solanum melongena (*Solanaceae* or nightshade family)

Soil preparation

- If either *phytophthora* blight or *verticillium* wilt is an issue, biofumigation has shown some effectiveness to reduce the incidence.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and amendments as needed. Plant eggplants in high raised beds covered with plastic mulch. Infrared transmitting (IRT) mulch will help warm up cold soil for the earliest plantings.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
130	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Colorado variety trial
- Irene has some verticillium wilt tolerance

Greenhouse and seeding guidelines

- EZ Seeder seeding plate #16
- Start seeds in the germination chamber or when you can keep your greenhouse warm both day and night. Germination is poor at lower temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
288	80°–90°	70°–80° daytime 65°–70° nighttime	Pot up into 38-cell trays or 3- to 4-inch pots after the first true leaves fully develop.	Put plug trays on a wire mesh bench to encourage air pruning.

Number of successions

- Some growers like to spread their risk by planting eggplant twice. In seasons when you transplant eggplant into the field under relatively cold conditions, the second crop produces much better.

Greenhouse guidelines

- When true leaves have developed, repot into 38-cell trays or 3- to 4-inch pots. Choose the size that allows you to hold the plant until the transplanting date. Bigger pots means bigger plants with more time in the greenhouse but also more work to transplant in the field.
- Keep the temperature around 70°–80° during the day and 65° at night for the best-quality plants. If you notice yellowing, make sure the temperatures are high enough during the day. When temperatures drop too low, premature flowers form that you will need to pick off.

- If necessary, feed plants with an OMRI-listed fertilizer to keep them healthy.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplant in the field when plants have enough of a root ball to hold the pot together.

Transplant tips

- The following tip is useful when you have harvest lanes, where every 8 or 10 beds are separated by a grass strip: Mark a 4-foot "walking break" on the plastic mulch every hundred feet and don't plant anything in that 4-foot strip. This will make harvesting easier by allowing you to easily pass through the crop when removing buckets. Instead of carrying the buckets of eggplants to the headland, one can walk through the crop (instead of over) to the left or right and place the buckets in the harvest lane to be collected by truck or other vehicle.
- Transplant in the field when the soil temperature is above 65° and before plants get too big.
- Planting eggplants early—before the soil is above 65° and when they can be exposed to cold nights—can set the plants back. Plant when they can get off to a successful start.
- Since eggplant is a tropical fruit, IRT plastic mulch is the preferred material to help warm the soil for early-planted crops.

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
2	18 inches	As deep as possible through plastic	

Cultivation procedures (with plasticulture)

- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder to control weeds. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Cultivation procedures (without plasticulture)

- Ideally, control weeds when they're in the white thread stage. When using precision cultivation tools, make sure plants are established and won't be uprooted by implements operating close to the crop.
- When plants aren't established, only use side knives or sweeps.
- When plants are established, use a finger weeder in combination with side knives for best weed control. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- Hand hoe or hand weed between plants.

Frost, disease and insect protection

- For the early plantings, use floating row covers to protect against frost, and consider keeping these covers on to protect against potato flea beetles as well. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. Remove covers at flowering for pollination.
- For control of Colorado potato beetles, move eggplants far away from last year's potatoes and eggplants. Use a *Bacillus thuringiensis* subsp. *tenebrionis* strain (as in the product Novodor™) to kill potato beetles in the larvae stage, with the rate depending on larvae size. You can use a spinosyn-based product like Entrust to kill adults, but only spot spray where there is a presence. To prevent killing beneficial insects and pollinators, avoid spraying during the day.
- To prevent anthracnose, use hot-water treatment of seeds, crop rotation and plastic mulch in combination with straw or a weed barrier.

- *Verticillium* wilt has many hosts in the field and it's very difficult to rely entirely on rotation to eliminate this disease. Using somewhat-resistant varieties like Irene is a good solution. To help reduce disease pressure, mix *Streptomyces iydicus* (as in the product Actinovate SP) and/or an extract of giant knotweed (as in the product Regalia) in a water solution and drench the complete tray before transplanting to prevent many soil- and foliar-borne pathogens, and to build immunity against them. Wear protective clothing and gloves when handling these products.
- Similarly, *Phytophthora* blight remains in the soil for a long time, and biofumigation has shown some effectiveness. (Additional information on *phytophthora capsici*.)

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Remove plastic and drip tape soon after the last harvest.
- Work under any mulch and crop residue to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow eggplants with rye and vetch. Adjust accordingly in other regions.

Escarole

Cichorium endivia (*Asteraceae* or *Compositae* family)

Soil preparation

- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Incorporate compost and amendments, and plant escarole in raised beds.
- Direct-seeded escarole requires a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Natasha, Leonida, Benefine

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	56°–85°	60°–75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Remove from the greenhouse 5 days before planting.

Transplanting on 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3	5 inches	Normal, don't bury the plant.	For full heads, plant at 9 inches.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	3	12–15	96 H 0.8	¼–½	22-17	
Sutton Jr.	10–20	50	8	¼–½		1 mph
Jang	3	6	XY 12	¼–½	Front 14/rear 10	

Number of successions

- Start planting escarole in the greenhouse 4 weeks before you expect to begin transplanting in the field. Follow with a second planting 12 days later. Reduce each following succession by 1 day until plantings are

weekly. In other words, the intervals between plantings will be 12-11-10-9-8-7-7-7, etc. This succession rate will reduce the incidence of several plantings coming in at the same time. Of course, the weather plays a large role in this as well.
- Continue planting escarole on a weekly basis until you run out of growing season. In the northern United States, we stop seeding escarole in the greenhouse around the second week in August for the November harvest. Increase the number of plants by the end of July through August if your markets demand a regular supply.

Cultivation procedures
- When direct seeding, create a seedbed 3 weeks before planting and shallowly cultivate after weeds emerge. Cultivate right before planting.
- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand weed or hoe between plants.

Deer, disease and insect protection
- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- For leafhoppers and whiteflies, use *Beauveria bassiana* (as in the product Mycotrol ESO) at nymph stage; repeat for three 5-day applications for best results. You'll see results after a week of applying. Use it when pest pressure is still low. When pressure is high, use a pyrethrum-based product (as in Pyganic EC 5.0 II). Make sure water is neutral, as either a low or high pH will make Pyganic EC 5.0 II ineffective. Pyrethrum breaks down quickly when exposed to UV light (it has a half-life of 12 hours) and is considered among the shortest-acting insecticides. It's also toxic to bees and other pollinators. For both reasons, apply a pyrethrum-based product in the evening.
- You can harvest escarole as a salad mix twice if you keep the crop very weed free.

Other cultural practices
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping
- You can plant a short-season vegetable crop like spinach or arugula after early-planted escarole.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested escarole with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Fennel

Foeniculum vulgare (*Apiaceae* or carrot family)

Soil preparation

- Fennel should not follow after other members of the carrot family, nor after potatoes, cereals or cucurbits, due to possible weed problems.
- Fennel does well after early lettuce and greens.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Incorporate compost and amendments, and plant fennel in raised beds.
- Direct-seeded fennel requires a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
90	0–160	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
128	70°–85°	65°–75°	Withhold water	Seed 2 seeds per cell and remove 1 after emergence. Add more vermiculite to the mix to increase drainage. Keep warm, since low temperatures can cause bolting. Put plug trays on a wire mesh bench to encourage air pruning.

Signs to watch for and what to do

- Consider a warmer location when plants are too small and don't develop well. Fennel doesn't require much water in its earlier stages, but later this changes. You might also require additional fertilization.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant tips

- Plants that lose some of their root system when replanted have a higher incidence of bolting.
- Fennel requires warm and relatively weed-free soil. Transplant early fennel and consider direct seeding for later plantings, if soil conditions allow.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth	Notes
2	9 inches	As deep as the plant can tolerate without the growing point getting buried	Irrigate after planting.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	2	6	96 H 1.0	¼–½	22-17	
Jang	2	3	YX6		Front 14/rear 10	

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Use a finger weeder in combination with side knives for the second cultivation. Alternatively, use side knives by themselves to avoid crop damage. Don't hill fennel, as this makes harvest more difficult and will increase basal rot.
- Thin to 9-inches apart and weed the rows to produce large bulbs.

Insect and disease protection

- Root and crown rot (*Rhizoctonia solani*, *Pythium* spp., and *Fusarium* spp.): Overhead irrigation and poor drainage in combination with cold soil conditions contribute to plants being affected by these pathogens. Good crop rotation and good hygiene (removing discarded plants from the field) are important as preventive measures. Transplanting when the soil is over 60° and dipping plants in *Trichoderma harzianum* (as in the product RootShield) are other good preventive measures.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Fennel benefits from drip irrigation. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant a short-season vegetable crop like spinach or arugula after early-planted fennel.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested fennel with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Garlic

Allium sativum (*ophioscorodon* variety—hardneck) (*Alliaceae* or onion family)

Soil preparation

- There are many options to prepare the land for a successful garlic crop. Here are 2 options:
- Leave the land in bare fallow the summer before planting, usually after 2 years of red clover. Bare fallow will remove both red clover and emerging weeds. Plow under the clover in June or July.
- To establish good weed-control tilth, you can also plant garlic after a regiment of cover crops. For example, plant a mix of oats and peas (at a rate of 100 lbs. per acre of each) as soon as the ground can be worked. Mow this cover crop and work it in when the oats have developed a flower stalk but not any pollen (anthesis), to avoid it becoming a weed. Follow this cover crop with a crop of buckwheat (at a rate of 80 lbs. per the acre). Again, work this under before the buckwheat is in full bloom to avoid it becoming a weed.
- Apply compost and amendments based on the results of a soil test before planting or right before incorporating buckwheat.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Prepare the seedbed 1–4 weeks in advance, and shallowly stale seedbed before planting to eradicate weeds, if possible. Don't disturb the soil too deeply, as this will bring up new weed seeds.
- Alternatively, prepare the beds no later than the end of August. (In the Northeast, this corresponds to 4–6 weeks before planting.) If the ground is dry, irrigate until the soil moisture is up to field capacity, and then place a silage tarp over the prepared beds. This will flush many annual weed seeds and reduce subsequent weed pressure. Remove the tarp when the weeds have died.
- Some growers plant garlic through black or white plastic mulch with much success. See this article for more information.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
40–120	0–150	0–150	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Hardneck garlic varieties (*Allium sativum* var. *ophioscorodon*)
  - Hardneck garlic varieties are generally hardier than softneck varieties. They produce garlic scapes in early summer by sending up a strong central stalk in spring. Hardneck types tend to form fewer and larger cloves per bulb than softneck varieties. Within the hardneck family, there are 9 sub-types of garlic: Purple Stripe, Marbled Purple Stripe, Asiatic, Glazed Purple Stripe, Creole, Middle Eastern, Turban, Rocambole and Porcelain. Within the hardneck type, the Porcelain (Music and German White), Marble Purple Stripe (Bogatyr), Purple Stripe (Chesnok Red) and Rocambole (German Red and Killarney Red) types are the best choice for growers in the northeastern United States and Canada.
- Softneck garlic varieties (*Allium sativum* var. *sativum*)
  - Softneck garlic varieties are the best ones to grow if you live in a milder climate. They don't form scapes, and they generally form several small cloves per head. Softneck varieties mature quicker than hardneck varieties. Sub-types within the softneck family include Silverskin and Artichoke.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3–4	7 inches	Plant garlic right side up as deep as the length of the garlic cloves.	Mulch with clean straw or hay at a rate of 3 lbs. of material per foot (a 40 lbs. square bale covers about 12.5 feet). Apply before the first deep freeze.

Planting procedures

- Crack hardneck garlic by hand to avoid bruising the cloves. Machine cracking can cause greater incidence of disease, especially *fusarium* basal rot. Sort cloves carefully for mites, garlic bloat nematodes and *fusarium*.
- Plant garlic as deep as the clove is tall, with the growing point facing up. Plant in an 8x8 grid for very high populations on a smaller scale, or for larger-scale growers, plant in rows 12–15 inches apart with 7 inches between cloves within the row.
- Planting hardneck garlic with a machine isn't advisable as the machine isn't able to get this right. Planting rightside-up is less important with softneck garlic.

Cultivation procedures

- Mulch directly after planting with straw or hay that is free of weed seeds. Depending on the maturity of the hay, it might break down faster than straw, so apply generously.
- Mulch will provide all the necessary weed control, making it unnecessary to cultivate.
- You'll need to hand weed on a regular basis the season after planting.

Other cultural practices

- You can apply additional nitrogen in early spring, but generally this isn't advised unless excessive rain over the winter washed out the N reserves. At a yield of 4,000–5,000 lbs. garlic only takes up approximately 40 lbs. of N. High N applications are associated with lower quality bulbs and greater incidence of disease. Mulching prevents some nutrient losses over the winter.
- You don't need to remove mulch to prevent yield loss due to cooler soil temperatures because moisture retention from the mulch may compensate for this.
- To increase bulb yield, remove (or harvest) garlic scapes as soon as they're visible. This happens in June in the Northeast. It may happen as early as May on the West Coast.

Insect and disease protection

- Check the soil for wireworms, as a high population will decrease yield because they feed on the garlic's root system. To avoid wireworm damage, include buckwheat as a cover crop before planting. Some results have been obtained using beneficial entomopathogenic nematodes. Also, applications of *Beauveria bassiana* have had promising results.
- Check for allium leaf miners. In southern regions, use exclusion netting to avoid an infestation. In northern regions, the moth generally emerges too late in the spring to do damage.
- Check garlic for possible infestations of white rot, dry rot and *Fusarium* basal rot. When a plant looks different, pull it out to inspect it, and remove all diseased plants from the field.

Double cropping and/or cover cropping

- Garlic is out of the ground by mid-July and can be followed by a number of transplanted vegetable crops that require relatively low fertility, like lettuce and escarole.
- Work under any harvest remains and straw. The mulch will absorb much of the available N during the breakdown process so it is essential to provide some additional fertilizer to successfully grow another vegetable crop.
- Alternatively, continue to cultivate the ground and follow with a cover crop later in the season.

Additional resources

- Here is a good research report on the effects of growing techniques on yield, grade and fusarium infestation levels in garlic.

Kale, Main Crop

Brassica oleracea (*Brassicaceae* or cabbage family)

Soil preparation

- Kale should not follow other cole crops.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Summer-planted kale does well when following a spring seeding of field peas, bell beans, barley and oats. In this case it doesn't need additional application of N.
- Incorporate compost and amendments, and plant kale as a field crop or in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	20–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial
- Darkibor, Winterbor, Redbor, Lacinato, Black Magic, Red Ursa

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	65°–85°	Cool	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Transplant readiness indicators

- Plants should easily come out of their cells. Plants should generally not be older than 5 weeks.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	12–18 inches	As deep as the plant can tolerate	Kale is a tough plant but can be decimated by flea beetles when not looked after.

Cultivation procedures

- Adjust mechanical transplanters so there is good contact between the plug or root ball and the soil. Ensure

plants are properly rooted before cultivation.
- Use sweeps (with torsions if possible) followed by a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder; but this works better when you use bare root transplants because tine weeders tend to uproot plugs.
- Hand hoe between plants as necessary.
- Use a finger weeder in combination with side knives for a second pass. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.
- If you need to cultivate a third time, use Lilliston rolling cultivators and hill carefully without burying the plants.

Disease and insect protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- To avoid *Alternaria* leaf spot, plant either far away or upwind from earlier planted cole crops and avoid overhead irrigation. Regular applications of *Bacillus amyloliquefaciens*, available as Double Nickel, have shown the best controls in research. *Bacillus subtilis*, available as Serenade, and mineral oil like JMS Stylet-Oil has shown some control for a few growers. Regular sprays with giant knotweed extract, such as Regalia, appear to reduce *Alternaria* as well by activating the plant's natural defenses against fungal and bacterial diseases.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping and/or double cropping

- Kale harvest can continue late in the season and generally doesn't get worked under before the winter. For best results with a cover crop, broadcast rye seed in August or September and mow the stalks down after the last harvest

Kale Mix and Mustard Greens

Brassica napus pabularia (*Brassicaceae* or cabbage family)

Use the following guidelines for any kale mix on the market, either by itself as Russian kale or in a mix with crops like mizuna.

Varieties

- Red Russian kale, Lacinato kale, red mustard, green mustard, mizuna, etc.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	50	2 or 3	Depth 2		Use spreader shoe
Sutton Jr.	10–20	30	6	¼		1 mph
Jang	5	12	YYJ 12 or YYJ 24	¼	Front 14/rear 10	

Other cultural practices

- Follow many of the cultural practices outlined in the Kale, Main Crop section.
- Some mixes allow for a second cutting.

Cover cropping and/or double cropping

- You can plant a short-season vegetable crop like salad mix or spinach after early-planted harvested kale greens.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested mustard or kale greens with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Kohlrabi

Brassica oleracea (*gongylodes* group) (*Brassicaceae* or cabbage family)

Soil preparation

- Kohlrabi should not follow other cole crops.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	20–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Indiana variety trial
- Winner, Kolibri for fresh market and Kossak for winter storage

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	65°–85°	Cool	Withhold water	You can seed 2 seeds per cell to increase transplanting speed. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Number of successions

- Spring: Kohlrabi doesn't do well during hot and dry weather. Plant kohlrabi 4 weeks before you're able to plant in the ground. Plant every 10 days for continuous spring to early summer harvest. In New York this is limited to 2–3 successions.
- Fall: Kohlrabi does well as a fall crop. In New York, seeding is resumed in July on a weekly basis until 4–5 weeks before the first frost. This allows continuous harvest until late November.

Signs to watch for and what to do

- Kohlrabi plants tend to get leggy. Provide enough light.
- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant readiness indicators

- Plants should easily come out of their cells. Plants should generally not be older than 5 weeks.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth	Notes
3	See Notes	Normal depth, level with the top of the root ball	Given the close spacing, a carousel planter works well. For single plants, use an in-row spacing of 5 inches. For double plants, use 10 inches.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.
- When new weeds emerge use side knives or sweeps only. Hand weed as needed.

Disease and insect protection

- Flea beetles
    - Cover the crop with floating row covers or insect netting after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- While kohlrabi is considered a short-season crop, and damage might be minimal, the presence of worms makes a crop unmarketable. Therefore, scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping and/or double cropping

- Early kohlrabi can be followed by a transplanted short-season vegetable crop like spinach or lettuce. Mow plants as low as possible with a flail mower. Incorporate crop residue.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested kohlrabi with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Leeks

Allium porrum (*Alliaceae* or onion family)

Soil preparation

- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and plant leeks in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial: This 2020 report showed that Lancia and Skater are good early performers. Chinook, Defender and Tadorna were good performers in the late fall. Generally, there was more discrepancy between the early and later varieties, and while Megaton is generally held as the gold standard, it was a middle of the road variety in the trials.

Greenhouse guidelines

- Start leeks in strip trays at a rate of 200–300 seeds per tray. Since leeks are started early in the season, germinate seeds in a germination chamber unless you can keep the greenhouse warm both day and night. Germination improves greatly at optimum temperatures.
- When the leeks have a few leaves, repot them into a 1020 tray that's well filled with a compost-based potting soil mix at a rate of 150 plants per tray.
- Place plug trays on a wire mesh bench to encourage air pruning.

Signs to watch for and what to do

- If necessary, feed with an OMRI-listed liquid fertilizer.
- Leeks are slow growers and it takes a few months before they can be transplanted in the field.
- Water carefully. Algae might form over time if the plants are too wet, and potassium and nitrogen will leach out.

Transplant readiness indicators

- Pencil thickness is desired but not always attainable. Transplant in late May to July.

Transplant tips

- Mix *Streptomyces lydicus* (as in the product Actinovate SP) and/or an extract of giant knotweed (as in the product Regalia) in a water solution and drench the complete tray before transplanting to prevent many soil- and foliar-borne pathogens, and to build immunity against them. Wear protective clothing and gloves when handling these products.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
2	5–9 inches	Plant deep, with just 1–2 inches of leaves remaining above the soil.	When leeks are pencil thickness, planting is usually done by hand. Punch a 1-inch hole 6 inches deep and place the leek in the hole. Ensure that roots aren't bent upwards.

Cultivation procedures

- Leeks are very sensitive to damage from aggressive cultivation. Take great care when cultivating leeks to avoid damage to leaves.
- Use sweeps (with torsions if possible) followed by a finger weeder 7–10 days after transplanting, or as soon as possible without damaging the plants. Alternatively, use a tine weeder.
- Hand hoe or hand weed between plants as necessary.
- Use a finger weeder in combination with side knives or sweeps for a second pass. Alternatively, to obtain slight hilling, use spring hoes in combination with side knives. Both methods effectively eliminate small weeds.
- If a third cultivation is possible, use hilling discs and hill up without damaging the plants.

Frost, disease and insect protection

- Watch for onion thrips, and control with a spinosyn-based product, such as Entrust, or *Beauveria bassiana*, as in the product Mycotrol ESO. With *Beauveria bassiana* you'll see results after a week of applying. Alternatively, use a mineral oil like JMS Stylet-Oil. Repeat applications of the selected product every 5–7 days. Don't exceed the maximum rate of 3 applications per season for Entrust. As direct contact with the pest is required for all these products, only spray at night, as thrips are nocturnal. Act when pest pressure is still low.
- Check for allium leaf miners. As this pest will emerge over several generations, follow local Extension guidance on when to use exclusion netting to avoid an infestation.
- Purple blotch (*Alternaria porri*) occurs mostly in the summer under wet and humid conditions. Plants that are weakened by thrips are more susceptible to this disease. Keeping the crop weed free to allow for air circulation, planting long rotations, practicing good sanitation (e.g., removing or incorporating diseased plant material) and avoiding excessive N are good preventive measures.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping and/or double cropping

- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested leeks with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Lettuce Heads, Main Crop

Lactuca sativa (*Asteraceae* or *Compositae* family)

Soil preparation

- Incorporate compost and plant lettuce in raised beds.
- Total nutrient uptake is 95 lbs. of N, 12 lbs. of P and 170 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York lettuce variety trial
- 2019 New York romaine variety trial: summary and report
- Popular green romaine varieties are Romulus, Green Forest and Coastal Star. In the red romaine series, Breen and Rouge D'Hiver are standard. Also try Winter Density with its smaller frame and good flavor and texture.
- Popular green leaf lettuce types are Bergam's Green and Green Star. New Red Fire is the standard large-frame red-leaf lettuce. Lolla Rossa is popular for a small-frame, red-leaf lettuce.
- Popular bibb types are Buttercrunch and Little Gem.
- Popular green Boston types are Nancy and Adriana, and Skyphos is a standard red Boston.
- Choosing the right Salanova type depends on its use and market. Most people grow it as a head to be cut as a salad mix. Some growers plant this on black plastic mulch and harvest 3 cuttings, as opposed to removing the head and removing the stem at the wash and pack station.

Greenhouse guidelines

- EZ Seeder seeding plate # 9

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	Below 80°	60°–75°	Withhold water	Sow 1 seed per cell. Put plug trays on a wire mesh bench to encourage air pruning.

Number of successions

- Start planting lettuce in the greenhouse 4 weeks before you expect to start transplanting in the field. Follow with a second planting 12 days later. Reduce each following succession by 1 day until plantings are weekly. In other words, the intervals between plantings will be 12-11-10-9-8-7-7-7, etc. This succession rate will reduce the incidence of several plantings coming in at the same time. Of course, the weather plays a large role in this as well.
- Continue seeding lettuce weekly until the growing season is over. In the northern United States we stop seeding lettuce in the greenhouse around the third week in August for the November harvest. Increase the number of plants during August if your markets demand a regular supply.

Seeding tips

- If the weather is too hot, keep flats in a cool location until seeds germinate.

Transplant readiness indicators

- Plants should easily come out of their cells. Plants should generally not be older than 3–4 weeks.
- Remove from the greenhouse 5 days before planting.

Transplanting in 5- or 6-foot raised beds

Rows	In-row spacing	Planting depth (inches)	Notes
3 to 5	6–12 inches	Do not bury plants. Leave the top of the root ball a little aboveground to avoid bottom rot.	Adjust the spacing based on the variety (see below).

- Romaine types: 12 inches in-row with a row distance of 15–18 inches
- Butterhead types 12 inches in-row with a row distance of 12–15 inches
- Greenleaf and red-leaf types: 10 inches in-row with a row distance of 15–18 inches
- Salanova types: 6 inches in-row with a row distance of 10–12 inches

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
2–3	6–12 inches	The top of the root ball should be above the soil line to avoid bottom rot.	Add kelp to water as a 0.5% solution in the water wheel planter.

Cultivation procedures (without plasticulture)

- Prepare the seedbed 1–2 weeks in advance, and shallowly stale seedbed before planting to eradicate weeds if possible. Don't disturb the soil too deeply as new weed seeds will be brought up.
- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe or hand weed between plants.

Cultivation procedures (with plasticulture)

- Cover plants with a floating row cover and support it with 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants.
- Cultivate with a rolling cultivator or Spyder to control weeds in between the plastic.
- If weeds between the rows are an issue, cover the areas with weed fabric as opposed to mulch, to avoid slug damage.

Deer, frost, disease and insect protection

- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- To prevent bottom rot (*Rhizoctonia*) and grey mold (*Botrytis*), provide drainage, avoid excessive overhead irrigation, control weeds and plant transplants ¼ inch above the soil surface.
- To prevent downy mildew (*Bremia lactucae*), use resistant varieties.
- To prevent viruses, use certified-disease-free seed, and reduce cross contamination by controlling whiteflies and aphids.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.

- Watch for aphids and whiteflies; place yellow sticky cards at plant height and check them at least twice a week. Control them with *Beauveria bassiana*, as in the product Mycotrol ESO. Repeat every 5–7 days. You'll see results a week after applying. Act when pest pressure is still low. Alternatively, you can use insecticidal soap (just against aphids), but when an infestation is heavy, use a pyrethrum-based product, such as PyGanic EC 5.0 II. This product requires a neutral pH to dissolve. Pyrethrum breaks down quickly when exposed to UV light (it has a half-life of 12 hours) and is considered among the shortest-acting insecticides. It's also toxic to bees and other pollinators. For both reasons, apply a pyrethrum-based product in the evening.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping and/or double cropping

- Lettuce is suitable for double cropping. As lettuce creates little crop residue, plant direct-seeded crops like arugula and spinach after it.
- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested lettuce with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Additional resources

- Organic Production and IPM Guide for Lettuce

Lettuce, Direct-Seeded Salad Mix

Lactuca sativa (*Asteraceae* or *Compositae* family)

Soil preparation

- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like lettuce don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding lettuce. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Varieties

- When downy mildew is an issue, only select resistant varieties. Favorites among growers are Salanova, Red Salad Bowl, Outredgeous, Green Salad Bowl and Defender. While Salanova is popular as a salad green, it's cost prohibitive for direct seeding. For growing this type, see the Lettuce Heads, Main Crop section.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	60	7	2		
Sutton Jr.	10–20	25–50	7–8	¼–½		Go at 1 mph. Reduce the seeding rate (by driving faster) when planting 17 rows to maintain a population of 20–40 seeds per square foot.
Jang	5	24	X24 or XY24		Front 14/rear 9 or 10	

Number of successions

- Start seeding salad mix as soon as you've prepared the ground in the spring. Follow with a second planting 12 days later. Reduce each following succession by 1 day until plantings are weekly. In other words, the intervals between plantings will be 12-11-10-9-8-7-7-7, etc. This succession rate will reduce the likelihood of several plantings coming in at the same time. Of course, the weather plays a large role in this as well.
- Continue seeding salad mix on a weekly basis until you run out of growing season. In the northern United States, we stop seeding salad mix around the first week of September for the November harvest. Increase the number of beds during the month of August if your markets demand a regular supply. Continue to seed salad mix in a high tunnel for season extension.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge. Mechanical weed control becomes very challenging when planting 17 rows.
- Hand weed in between plants but make sure you don't pull up any soil. A 17-row salad mix has the advantage that the leaves are prevented from falling horizontally and so tends to be cleaner than planting it in 9 rows.

Cover cropping and/or double cropping

- You can plant another short-season vegetable crop like spinach, radish or arugula after an early-harvested salad mix. Mow plants as low as possible with a flail mower. Incorporate crop residue.
- For later dates, work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested salad

mix with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Melons/Cantaloupes

Cucumis melo (*Cucurbitaceae* or cucumber family)

Soil preparation

- Melons should not follow after other cucurbits or nightshades, but they follow well after cole crops, leguminous green manures or sweet corn.
- Total nutrient uptake is 158 lbs. of N, 27 lbs. of P and 155 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost and other amendments, and plant melons on high raised beds covered with plastic mulch.
- Where *phytophthora* (*phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Indiana variety trial
- Athena is still the most popular variety among organic growers.

Greenhouse guidelines

- EZ Seeder seeding plate #5
- If starting melons early in the season, germinate seeds in a germination chamber, unless you can keep your greenhouse warm both day and night. Germination improves greatly at optimum temperatures.
- Grow melons in a 1020 tray with 24 cells if you want more flexibility at planting time. Melons in a 38-cell tray can get leggy when left too long in the greenhouse.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	80°–90°	75°	Reduce water and temperature for 1 week.	Put plug trays on a wire mesh bench to encourage air pruning. Plants should be ready for transplanting within 4 weeks.

Number of successions

- Start seedlings 3 weeks before the last frost date. Plant a short-season variety.
- The number of successions is based on the willingness to risk a crop loss due to downy mildew. In the Northeast, downy mildew pressure is highest from the middle of July through August. So far, there are no downy-mildew-resistant cantaloupe varieties.
- For continuous harvest, the next successions are planted on a 10- to 14-day schedule until 2 ½ months before the first frost.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.

Transplant tips

- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they can't, their roots will be damaged and the plants have a higher fatality rate.
- Lay plastic mulch at least a week before planting to allow weed seeds to germinate and the soil to warm.

Use infrared transmitting (IRT) mulch for early plantings. Planting on the same day as laying plastic will cause weed pressure in the planting hole.

- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.
- To help resist cucumber beetle damage, dissolve Kaolin clay (as in Surround) in plenty of water and drench the complete tray in the solution before transplanting.

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
1	12 inches	Normal	Add kelp to water as a 0.5% solution in the water wheel planter. Use wider in-row spacing for later plantings.

Cultivation procedures

- When using plasticulture, plant at least a week after laying the plastic mulch to allow weeds to germinate under the plastic. Use IRT plastic to warm the soil earlier in the season.
- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Deer, frost, disease and insect protection

- Plant early plantings downwind from later varieties, as both powdery and downy mildew are windborne.
- For your earliest plantings, use floating row covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If frost protection or providing a warm environment isn't necessary, you can use the longer-lasting insect covers to provide protection against beetles.
- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis*, as in CEASE, and potassium bicarbonate, as in MilStop SP. Sulfur causes phytotoxicity in melons, so be careful if you're applying sulfur in any form to control powdery mildew. Also, consider using tolerant or resistant varieties. A full list of OMRI-listed control products on powdery mildew is available from CALS.
- Downy mildew can be somewhat controlled with the biological *Pseudomonas aeruginosa*, as in Zonix. Also, consider using tolerant or resistant varieties.
- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- When melons have sized up, hold back on irrigation to avoid splitting.

Cover cropping and/or double cropping

- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested cantaloupes with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Onions

Allium cepa (*Alliaceae* or onion family)

Soil preparation

- Onions should not follow other members of the allium family. Also, plant onions away from garlic due to the presence of overwintering thrips.
- Total nutrient uptake is 145 lbs. of N, 25 lbs. of P and 155 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Incorporate compost and amendments and plant onions in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- Oregon variety trial
- Washington State variety trial

Greenhouse guidelines

- EZ Seeder seeding plate #16
- Since onions are started early in the season, germinate seeds in a germination chamber unless you can keep the greenhouse warm both day and night. Germination improves greatly at optimum temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	60°–85°	60°–65° daytime; 55°–60° nighttime	Withhold water	Sow 3–4 seeds per cell. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.
128	60°–85°	60°–65° daytime; 55°–60° nighttime	Withhold water	Sow 1 seed per cell. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Transplant tips

- While it's a personal choice to plant onions in a clump or as individual transplants, what matters most is that onions cannot be given too much space in the field. While onions planted at low populations become quite large, the incidence of bacterial rot is much higher, leading to crop loss.

Signs to watch for and what to do

- Onions take a considerable amount of time from seeding to transplanting. Over time, nutrients in the small cell are used up or leached out from overwatering. If you notice nutrient deficiency or poor growth, feed with an OMRI-listed liquid fertilizer.
- Clip tops off tall onion leaves to avoid falling over. Transplant after a good "haircut."

Transplant readiness indicators

- Transplant in the field when plants have enough of a root ball to hold the pot together.

Transplant tips

- Mix *Streptomyces lydicus*, as in the product Actinovate SP, and/or an extract of giant knotweed, as in the product Regalia, in a water solution. Drench the complete tray before transplanting. This prevents many soil- and foliar-borne pathogens, and builds immunity against them. Wear protective clothing and gloves when handling these products.
- Planting in plastic mulch can increase onion yield in multiple ways. The higher soil temperature in April and May results in bigger onions. Drip irrigation along with the mulch improves soil moisture. Additionally, you can apply a silver strip to the plastic to repel thrips away from the onions.

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
3–5	individual plants: 4 inches; clumps: 9 inches	Don't plant onions too deep in the planting holes, as they could slip underneath the plastic mulch	Use water generously when using the water wheel planter.

Cultivation procedures

- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Watch for onion thrips, and control with a spinosyn-based product, such as Entrust, or *Beauveria bassiana*, as in the product Mycotrol ESO. With *Beauveria bassiana* you'll see results after a week of applying. Alternatively, use a mineral oil like JMS Stylet-Oil. Repeat applications of the selected product every 5–7 days. Don't exceed the maximum rate of 3 applications per season for Entrust. As direct contact with the pest is required for all these products, only spray at night, as thrips are nocturnal. Act when pest pressure is still low.
- Check for allium leaf miners. As this pest will emerge over several generations, follow local Extension guidance on when to use exclusion netting to avoid an infestation.
- *Botrytis* leaf blight (fungus), *Xanthomonas* leaf blight (bacterial) and downy mildew (*Peronospona destructor*, a fungus) are all problems you can avoid with long rotations, good sanitation (removing or incorporating diseased plant material), certified-disease-free seed (or hot water treatment) and good water management.
- Purple blotch (*Alternaria porri*) occurs mostly in the summer under wet and humid conditions. Plants that are weakened by thrips are more susceptible to this disease. Keeping the crop weed free to allow for air circulation, planting long rotations, practicing good sanitation (e.g., removing or incorporating diseased plant material), and avoiding excessive N are good preventive measures.
- Many bacterial bulb diseases develop between pre-harvest and storage. Tips for controlling this disease:
    - Avoid damage to onions during harvest. Prematurely topping onions can cause them to contract bacterial bulb diseases. If topping is necessary, wait until 90% of tops have lodged and leave at least 4 inches of stem above the bulb.
    - A late release of nitrogen from a generous compost application, and/or a low onion population

per square foot results in higher disease pressure.
    - Excessive moisture combined with high temperatures also causes higher disease pressure. Avoid using overhead irrigation late in the season.
    - Harvest when onions are mature, which is when 90% of the leaves have lodged.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- When onions are starting to lodge, hold back on irrigation to avoid bacterial rot. Also, make sure that plastic mulch isn't touching the onions. Open the holes as wide as possible to avoid burn damage. While soil warming is a benefit of plastic mulch early on, at this point it can become a liability as the leaves no longer shade the plastic. Removing the mulch is an option, but take great care not to damage the onions.

Cover cropping and/or double cropping

- After the last harvest, remove plastic mulch and drip tape. Work under any plant remains to avoid insect or pathogen buildup and plant a cover crop. In the northern United States and Canada, you can plant oats and peas after onions, or rye and vetch at later dates. Adjust accordingly in other regions.

Onions, High Tunnel (Overwintering)

Allium cepa (*Alliaceae* or onion family)

For more production information, see the main Onions section.

Soil preparation

- Incorporate compost or leave it on the soil surface. Plant onion sets in raised beds.
- Total nutrient uptake is 145 lbs. of N, 25 lbs. of P and 155 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Massachusetts variety trials for overwintering onions

Planting information

- Plant onion sets around September in an 8x8 inch grid.

Rows	Distance	Planting depth	Notes
5–6	8 inches	Plant onion sets just below the surface like garlic.	Cover onions with mulch or a thin layer of compost and add sufficient moisture to the soil to get them through the winter.

Frost, disease and insect protection

- Because you're growing these onions in a high tunnel over the winter, you won't have any pest issues aside from any pests already living in the tunnel. Apply good sanitation in the tunnel by removing old plant material.

Other comments

- Onions are ready to harvest starting in June in the Northeast. Adjust harvest and planting dates according to your region.

Parsley

Petroselinum crispum (*Asteraceae* or carrot family)

Soil preparation

- Apply compost and other amendments based on the results of a soil test.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost and amendments, and plant parsley in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–200	6.0–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Darki (curly leaf) and Italian Dark Green (flat leaf)

Greenhouse guidelines

- EZ Seeder seeding plate #9
- When starting parsley early in the season, germinate seeds in a germination chamber unless you can keep the greenhouse warm both day and night. Germination improves greatly at optimum temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°	65°	Withhold water	Sow 3–5 seeds per cell. Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Number of successions

- As you can take several cuttings from parsley, it's up to you how often you want to reseed it.

Signs to watch for and what to do

- Because parsley plants remain in their cells a long time before transplanting, you might have to start applying an OMRI-listed liquid fertilizer to the water. Follow the directions on the product to avoid salt buildup in the medium.
- Overwatering can also cause poor growth. Algae may form over time if the plants are kept too wet, and potassium and nitrogen may leach out.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Plants should pull out of their cells easily, but they might become rootbound when left too long in the greenhouse.

Transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
3	12 inches	Same level as potting medium	Use a 12-inch sprocket or 12-inch wheel.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- You'll need to follow up with hand hoeing. Crawling many times through the crop to keep it weed free is a common procedure with this crop, as you can cut it over 3 times per season. To keep it productive, you might have to feed it with an OMRI-listed granular fertilizer.
- When using plastic mulch, plant parsley at 3 rows, 12 inches apart, and fertigate with an OMRI-listed liquid fertilizer after each cutting.

Disease and insect protection

- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- *Septoria* leaf spot (*septoria apiicola*) occurs mostly on flat Italian parsley. A hot-water treatment will prevent this seedborne issue.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping and/or double cropping

- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested parsley with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Parsnips

Pastinaca sativa (*Asteraceae* or carrot family)

Soil preparation

- Parsnips should not follow after other members of the carrot family, and ideally not after potatoes and cucurbits.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Incorporate compost and plant parsnips in raised beds or ridges.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like parsnips don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date (depending on the time of year). This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
150	0–160	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Maine parsnip evaluation
- Javelin and Lancer are popular varieties resistant to canker.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	15–25	15	½		Planet Jr. seeders won't allow for any singulation due to the shape of the seed. Thinning will be required.
MaterMacc	3	20	192 H 2.0	½	22-19	
Jang	3	20	MM 12 or M12			Jang seeders won't allow for any singulation due the shape of the seed. Thinning will be required.

Cultivation procedures

- Cultivate or flame weed right before planting.
- Flame weed again before parsnips come up. For accurate timing, put a glass plate over a small area of 1 row just after seeding. When the seedlings under the glass emerge, it's time to flame weed. Basket weed with soil busters in front of the baskets, since the soil will be hard at this point.
- After parsnips are up use a basket weeder or wheel hoe when weeds are still in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they

emerge.
- Use a finger weeder in combination with side knives for a second pass before the crop closes the rows. Alternatively, use spring hoes in combination with side knives if you want slight hilling of the crowns, which will also result in greater weed control.
- When hand weeding, avoid working in full sun and when temperatures are high because it's common to develop an allergic reaction from exposure to the leaves in the form of a skin rash. Provide workers with gloves and require them to work only with long sleeves and pants.

Deer, disease and insect protection

- Check the soil for wireworms, as a high population can cause parsnip root to become unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Promising results have also been obtained applying *Beauveria bassiana*.
- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- Parsnip canker (*Itersonilia perplexans*): To avoid canker on parsnips, choose tolerant or resistant varieties, slightly hill the plants during cultivation, apply a long rotation and practice good sanitation after harvest by removing all diseased parsnips.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Cover cropping procedures

- November-harvested parsnips rarely allow for establishing a cover crop. Over seeding isn't much of an option as the forking or lifting of the roots during harvest will damage the cover crop.
- Remove all discarded parsnips from the field to avoid a buildup of pathogens.

Peas, Sugar Snap, Snow and Shelling

Pisum sativum (*Fabaceae* or legume family)

Soil preparation

- Incorporate compost and plant peas in raised beds.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Total nutrient uptake is 170 lbs. of N, 22 lbs. of P and 80 lbs. of K.
- Peas follow well after a light winter cover crop of oats, or when no cover crop was planted the previous winter.
- As peas are among the first crops to plant, there's no opportunity to flush out the first germinating weeds in the bed. Alternatively, prepare the bed the previous season in early October and cover it with a silage tarp.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
50	0–120	0–160	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Peas are grouped by how they're used and picked (shelling peas, snow peas and sugar snap peas) and how they're cultivated. All of the shelling, snow and sugar snap types are available in both determinate and indeterminate types. PLS 595 is an excellent semi-indeterminate shelling pea. Indeterminate sugar snap continues to be the standard for high-quality sugar snap peas.
- Washington State, Oregon, Wisconsin, Minnesota and New York variety trial
- New York variety trial
- Shell pea varieties and their resistance to specific diseases and physiological disorders

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	2–3	25	36	½–1 Depth 4 or deeper. Only use regular shoe		Mix with inoculants. It's important to bury seeds completely. Plant 2 rows 4 inches apart on the middle of the bed for indeterminate types, or 3 rows 18 inches apart for determinate types.
Earthway	2–3	10	Peas disc	½–1		Skips easily
Jang	2–3	6	B or C12	½–1	Front 14/rear 9	The Jang seeder doesn't perform well at planting peas.
MaterMacc	2–3	12	144 H 4.5	½–1	17-19	12 seeds per foot when 2 rows are planted 30 or 36 inches apart.

Transplanting and planting information

- Inoculate peas with *Rhizobium leguminosarum biovar viciae* for proper N fixation.
- You can also transplant peas using a paper-pot planter, which allows you to get good germination and an

early start. Some considerations:
    - Planting peas with a paper-pot planter allows for some season extension. You get excellent germination in the greenhouse when the ground is too cold to germinate in a high tunnel.
    - As a slightly higher density is ideal for trellised peas, it's important to avoid gaps by using high-germinating seed. Plant when the pea plants have developed their first true leaves. Planting later leads to transplant shock.
    - Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate the first week until roots are established.
- For extra-early peas, transplant in a high tunnel. Use the pot spacing of 2 inches (CP303), which is the smallest-available pot spacing.
- For indeterminate varieties, seed or plant 2 rows of peas by traveling twice over the same bed with a 1-row planter or paper-pot planter. Walk carefully so each row is 4 inches apart from the other.
- For indeterminate peas, plant peas 2–3 rows to a bed at either 30, 36 or 18 inches apart, depending on wheel track spacing.

Cultivation procedures

- Basket weeders and spring hoes are useless if the crop is planted at 2 rows, 4 inches apart in the center of the bed. To keep the crop clean, use your cultivation toolbar and mount side knives for a 1-row set up, and cultivate as close as possible to the germinated peas. Do this when weeds are in the white thread stage.
- When planting determinate types, use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- If a second pass is possible, use sweeps or side knives only. Precision cultivation tools can damage peas.

Deer, insect and disease protection

- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't try to jump this fence without checking out the first fence, so electrifying the second fence often isn't needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- To avoid plant pathogens, choose resistant or tolerant varieties.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.
- Trellis peas the same way you would trellis tomatoes. (See the Tomatoes section for a description.)

Double cropping and/or cover cropping

- After the last harvest, remove the trellis and posts. You can follow early peas with a transplanted short-season vegetable crop like spinach or lettuce. Mow plants as low as possible with a flail mower. Incorporate crop residue.
- If you aren't planting another crop after peas, incorporate any harvest remains to avoid insect or pathogen buildup, and plant a cover crop, such as oats and peas during September, or rye and vetch at later dates.

Additional resources

- Organic Production and IPM Guide for Peas

Peppers

Capsicum annuum (*Solanaceae* or nightshade family)

Soil preparation

- Where *phytophthora* (*phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and plant peppers on high raised beds covered with plastic mulch. Infrared transmitting (IRT) mulch will help warm up cold soil for your earliest plantings.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
150	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York bell pepper variety trial
- Oregon Italian pepper variety trial
- Wisconsin red pepper variety trial
- Popular bell pepper varieties are X3R Red Knight, Sweet Sunrise, King of the North, King Arthur and California Wonder.
- Popular sweet specialty peppers are Carmen, the Lunchbox series, the Cornito series and Shishitos.
- Popular hot peppers are Bastan (poblano), Ancho (poblano), Jalafuego (jalapeño) and Cherry Bomb (hot).

Greenhouse guidelines

- EZ Seeder seeding plate #16
- Germinate seeds in a germination chamber unless you can keep your greenhouse warm both day and night. Germination improves greatly at optimum temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
288	80°–90°	80° day; 60° night	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning.

Number of successions

- There's usually only 1 main planting. Some growers like to spread their risk and plant peppers twice. When transplanting peppers into the field in a season with relatively cold conditions, the second crop produces much better.

Signs to watch for and what to do

- When true leaves have developed, repot into 38-cell trays or 3- to 4-inch pots. Choose the size that allows you to hold the plant until the transplanting date. Bigger pots mean bigger plants with more time in the greenhouse but also more work to transplant in the field.
- Keep the temperature around 80° during the day and 60°–65° at night for best-quality plants. When

temperatures drop too low, premature flowers form that you'll need to pick off.
- If necessary, feed plants with an OMRI-listed fertilizer to keep them healthy.

Transplant readiness indicators
- Harden plants off by moving them outside during the day, exposing them to some direct sun and wind.
- Make sure the plants have enough root ball to hold the pot together.

Transplanting tips
- Transplant in the field when soil temperature is above 65° and before plants get too big. Plants that are lush don't perform well in the field.
- Planting peppers early—before the soil is above 65° and when nights are cold—can set them back. Only plant when they can get off to a successful start.
- Since peppers are a tropical fruit, IRT plastic mulch is the preferred material to help warm the soil for early-planted crops.
- The following tip is useful when you have harvest lanes, where every 8 or 10 beds are separated by a grass strip: Mark a 4-foot "walking break" on the plastic mulch every hundred feet and don't plant anything in that 4-foot strip. This will make harvesting easier by allowing you to easily pass through the crop when removing buckets. Instead of carrying the buckets of peppers to the headland, one can walk through the crop (instead of over) to the left or right and place the buckets in the harvest lane to be collected by truck or other vehicle.

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
1–2	12 inches	As deep as the plant allows	

Cultivation procedures (without plasticulture)
- Ideally, control weeds when they're in the white thread stage. The tools you use will depend on whether the plants are well established or not.
- When plants are established, use precision cultivation tools such as a finger weeder in combination with side knives for best weed control. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives. These tools will eliminate small weeds effectively.
- When plants aren't established, precision tools can uproot them. So, use side knives or sweeps only.
- Hand hoe or hand weed between plants.

Cultivation procedures (with plasticulture)
- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection
- Mix *Streptomyces lydicus* (as in the product Actinovate SP) and/or an extract of giant knotweed (as in the product Regalia) in a water solution and drench the complete tray before transplanting to prevent many soil- and foliar-borne pathogens, and to build immunity against them. Wear protective clothing and gloves when handling these products.
- For early plantings, use floating row covers to protect against frost, but remove them once the danger of frost has passed. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Corn earworms are a problem in peppers when they fly in from sweet corn during the second

generation—usually around the third week in July, depending on your location. Control them with frequent releases of the predator *Trichogramma ostriniae* once the second generation has hatched. Release them at high numbers for this to be effective. A spinosyn-based product like Entrust isn't very effective as it's more difficult to get direct contact with the larvae. Eggs often hatch on the fruit, where the larvae create an opening that causes the fruit to prematurely ripen and then rot.

- Pepper maggots are a new issue and are often undetected until the customer opens the fruit. Damage is most visible on glossy varieties like hot cherry peppers. Starting to spray with a neem-based product like Neemix every seven days when you first spot signs of damage seems to provide some control. This is usually around mid-July, depending on your location.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Remove plastic and drip tape soon after the last harvest.
- Work under any harvest remains to avoid insect or pathogen buildup, and plant a cover crop. In the northern United States and Canada, you can follow summer- and early-fall-harvested peppers with a cover crop of oats and peas in September, or rye and vetch planted at later dates. Adjust accordingly in other regions.

Potatoes

Solanum tuberosum (*Solanaceae* or nightshade family)

Soil preparation

- Total nutrient uptake is 180 lbs. of N, 26 lbs. of P and 225 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and create a fluffy seedbed, as potatoes need much air to prosper.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
150	0–240	50–350	5.0–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- North Dakota variety trial
- Idaho, Washington State and Oregon variety trial
- Michigan variety trial
- Yellow: Keuka Gold, Natasha, Satina, Nicola
- White: Kennebec, Green Mountain, Lehigh
- Red: Red Maria, Adirondack Red, Chieftain
- Russet: Amey Russet, Gold Rush
- Purple: Adirondack Blue, Magic Molly
- Fingerling: Yellow Finn

Planting in the field with a potato planter

Rows	In-row spacing	Planting depth (inches)	Notes
2	See Notes.	As deep as the planter allows the seed potatoes to be dropped in the furrow, but no deeper than 2–3 inches.	For regular potatoes, use an in-row spacing of 7–9 inches. For russets, use 12 inches. 100 lbs. of seed potatoes can cover approximately 600 row feet. Any potatoes larger than B size need to be cut into smaller pieces. Make sure each piece has at least 1 eye.

Cultivation procedures

- Use a tine weeder or rolling cultivator when weeds are in the white thread stage. Make sure tubers are well rooted at this point.
- Use a ridger or large discs to hill the potatoes, and drive carefully to avoid burying them.
- This will take several passes and as the potato plants grow, you can become increasingly more aggressive in the amount of soil you mount up. The objective is to cover all emerging weeds after each pass.
- Potatoes are fast-growing plants, and the shade from their leaves will control weeds until they're ready for harvest.

- Weed control becomes very challenging when leafhopper control isn't adequate and potato leaves are damaged to the point that they're defoliated before developing a hard skin. Exposed soil will allow new weed seeds to germinate. Mechanically harvesting potatoes before they have developed a skin will create many post-harvest issues, so you're left with little choice but to leave the potatoes in the ground. There is no good way of controlling weeds at this stage, as additional ridging or hilling will either expose the tubers to sunlight or damage them.

Frost, disease, and insect protection

- Plant potatoes when soil temperature is above 50°.
- Prevent potato scab (*Streptomyces scabies*) by selecting resistant varieties, selecting ground with a low pH (lower than 5.2), broad crop rotation and timely irrigation.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Check the soil for wireworms, as a high population can cause yield decline. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Promising results have also been obtained applying *Beauveria bassiana*.
- For Colorado potato beetles move potatoes as far away from last year's plot as possible. Use *Bacillus thurigiensis* subsp. *tenebrionis*, available as a product in Novodor™, for killing beetles in the larva stage. Use Entrust only to kill adult potato beetles. Potatoes can host a great variety of beneficials, so avoid spraying the whole field. Use a backpack sprayer for spot spraying.
- Potato leafhoppers can be a big problem for organic potato growers. For leafhopper control, use *Beauveria bassiana* (as in the product Mycotrol ESO) at nymph stage. You'll see results after a week of applying. Use it when pest pressure is still low. When pressure is high, use a pyrethrum-based product (as in PyGanic EC 5.0 II). Make sure water is neutral, as either a low or high pH will make PyGanic EC 5.0 II ineffective. Pyrethrum breaks down quickly when exposed to UV light (it has a half-life of 12 hours) and is considered among the shortest-acting insecticides. It's also toxic to bees and other pollinators. For both reasons, apply a pyrethrum-based product in the evening.
- Late blight can only be controlled preventively. Once the disease is visible, you're too late. Follow local Extension updates on whether late blight has been observed in your region, and start applying an OMRI-listed product. Here are some options: a weekly spray of a biosurfactant based on *Pseudomonas aeruginosa*, as in the product Zonix. OMRI-listed coppers combined with a spreader sticker/adjuvant can be quite effective. Some growers have success using mineral oil, as in JMS Stylet-Oil, in lieu of a spreader sticker. Don't use both adjuvants and mineral oil, as this will cause crop damage. Weekly applications of a giant knotweed extract (*Reynoutria sachalinensis*), as in the product Regalia, helps the plant's immune system. Note that because late blight can become airborne, it will affect both the foliage and the tuber, but waiting to harvest until all foliage has decomposed may avoid crop loss, because phytophthora can only survive on living tissue.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop. When potatoes flower, ensure they have abundant moisture because this is a critical stage in their development.

Double cropping and/or cover cropping

- Potatoes can be followed by rye and vetch.

Additional resources

- Organic Production and IPM Guide for Potatoes

Pumpkins

Cucurbita pepo (*Cucurbitaceae* or cucumber family)

Soil preparation

- Pumpkins should not follow after other cucurbits or nightshades because of the risk of blight caused by *Phytophthora capsici*. They follow well after cole crops, and leguminous green manures or sweet corn.
- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost, and plant pumpkins in raised beds or grow them as a field crop.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Pennsylvania and Indiana variety trial

Greenhouse guidelines

- EZ Seeder seeding plate #5 or seeded by hand
- Use a 1020 tray with 24 pots for more light, which results in stockier plants. When using a 38-pot tray, make sure you transplant before they get leggy.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	75°	75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take outside 1 week before planting in the field.

Signs to watch for and what to do

- Pumpkins grow fast. Make sure to transplant them to the field before they get leggy.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they can't, their roots will be damaged and the plants have a higher fatality rate.

Transplant tips

- If using plastic mulch, lay it at least a week before planting to allow weed seeds to germinate and the soil to warm. Planting on the same day as laying plastic will cause weed pressure in the planting hole.
- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.
- To help resist cucumber beetle damage, dissolve Kaolin clay (as in Surround) in plenty of water and drench the complete tray in the solution before transplanting.

Water wheel planter

Rows	In-row spacing	Planting depth (inches)	Notes
1	12 inches	Same level as potting medium	

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	1	1	9 H 4.5	½	22-18	

Cultivation procedures (without plasticulture)

- You can use your regular cultivation setup with side knives if growing pumpkins in the traditional bed system. Don't use any finger weeders. Precision cultivation can damage cucurbits. Keep some distance from the plants to avoid this.
- You can use a regular field cultivator and drive between rows if you planted pumpkins 10–12 feet apart.
- Hand hoe between plants.

Cultivation procedures (with plasticulture)

- When using plasticulture, plant at least a week after laying the plastic mulch, to allow weeds to germinate under the plastic. Use infrared transmitting (IRT) plastic to warm the soil earlier in the season.
- After transplanting, cultivate once or twice in between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass, because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Plant upwind from early plantings of other cucurbits such as summer squash or melons, as both powdery and downy mildew are windborne.
- Use floating row covers or insect covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If frost protection or providing a warm environment isn't necessary, you can use the longer-lasting insect covers to provide protection against beetles.
- Keep squash bug populations under control by rotating far from where you grew squash the previous year. Unfortunately, squash bugs will shelter in the straw between plastic mulch.
- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis*, as in CEASE, and potassium bicarbonate, as in MilStop SP. Sulfur causes phytotoxicity in melons, so be careful if you're applying sulfur in any form to control powdery mildew.
- Downy mildew can be somewhat controlled with the biological control *Pseudomonas aeruginosa*, as in Zonix. Also, consider using tolerant or resistant varieties.
- A full list of OMRI-listed control products available for cucurbits, and their efficacy, is available from CALS.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Incorporate any remaining plants, weeds and fruit into the soil. Plant a cover crop like rye and vetch to reduce future squash bug populations.

- If weed pressure was high and caused a lot of seed rain, it's better to refrain from any fall tillage. Allow the weed seeds to decay and be eaten by birds and rodents over the winter months to reduce future weed pressure. Unfortunately, this is contradictory to keeping squash bug populations under control.

Additional resources

- Pumpkin and Squash Fertility Management

Radishes

Raphanus sativus (*Brassicaceae* or cabbage family)

Soil preparation

- Radishes should not follow other cole crops.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting. Alternatively, you can side-dress it during cultivation. Divide the recommended rate of the soil test in half if side-dressing.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like radishes don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Create a fine and firm seedbed when direct seeding radishes. Prepare the seedbed a few weeks before planting to encourage weeds to germinate. This provides the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date (depending on the time of year). This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
50	0–125	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial
- Crunchy Royale, Sora, French Breakfast, Easter Egg, and the watermelon radish variety Red Meat for storage.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	15	8	2–4		Use row covers after planting for flea beetle control
Sutton Jr.	5	20	16	¼–½		1 mph
Jang	5	12	X12 or X24		24 Holes: front 11/rear 13; 12 holes: front 14/rear 9	

Number of successions

- Under ideal growing conditions, radishes take a month to mature from seeding to harvest.
- Plant radishes as soon as you've prepared the ground in the spring. For continuous harvest, plant the next

succession when the cotyledons are fully developed. Depending on your location, continue successions until approximately the first frost date. In New York, this means that the first successions have an approximate interval of 14 days that narrows to an interval of 7 days by late May.
- Watermelon radishes for storage are planted in mid- to late August in New York. Adjust planting date according to your region.

Cultivation procedures
- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- You seldom need hand weeding when planting radishes at the correct population.

Frost, disease and insect protection
- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Check the soil for wireworms, as a high population can cause radishes to become unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Promising results have also been obtained applying *Beauveria bassiana*.
- Cabbage maggots: To reduce infestations of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting, as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - Fall-planted radishes don't need any protection after the third generation of flea beetles, which is around September 1 in the Northeast. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.

Other cultural practices
- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping
- You can plant fall lettuce or spinach after early radish crops.

Rutabagas

Brassica napus (*Brassicaceae* or cabbage family)

Soil preparation

- Rutabagas should not follow other cole crops.
- Total nutrient uptake is 165 lbs. of N, 10 lbs. of P and 200 lbs. of K.
- A soil test will determine how much compost to apply.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like rutabagas don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Direct-seeded rutabaga requires a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
60	0–125	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
72, 98 or 128	75°	65°–75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Signs to watch for and what to do

- Rutabagas perform poorly in a cell pack and tend to look a bit scraggly. It takes them a bit longer to develop a strong root system in the cells. As a result, many growers direct seed rutabagas.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Plants are ready when they come easily out of their cells. Be extra careful when handling the young seedlings, as the leaves are thin. Plants shouldn't be older than 5 weeks.

Transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
3	9 inches	Same level as the soil	Use 9-inch sprocket

Direct Seeding Information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	25	1–2	Depth 2		Only use regular shoes
MaterMacc	3	3	24 H 1.0	¼–½	22–17	
Jang	3	4–6	Y 12		Front 14/rear 10	

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.
- Use spring hoes in combination with side knives or sweeps for a second cultivation before a second flush of weeds emerges. Remove any remaining weeds by hand. The spring hoes will slightly hill and bury small, emerging weeds effectively.

Frost, disease and insect protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Check the soil for wireworms as a high population can cause roots to become unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce and alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Also promising results have been obtained when applying *Beauvaria bassiana*.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence or after transplanting to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestation of cabbage maggots on young seedlings, cover seedlings with floating row covers or insect netting, as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Rutabagas are generally harvested too late to be followed by a cover crop.

Scallions

Allium cepa (*Alliaceae* or onion family)

Soil preparation

- Scallions should not follow any members of the allium family or be planted next to garlic due to the presence of overwintering thrips.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and plant scallions in raised beds.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–200	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Ishikura, Nabechan

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
128	60°–85°	60°–65° daytime; 55°–60° nighttime	Withhold water	7–9 seeds per cell. Take plants outside 1 week before planting in the field.

Number of successions

- Scallions can be planted all season, starting in early spring and entering fall. Start with a 14-day interval and reduce each following succession by 1 day until plantings are weekly. In other words, the intervals between plantings will be 12-11-10-9-8-7-7-7. The last seeding is usually in August.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Plants are ready when they come easily out of their cells.

Transplant tips

- You can also transplant scallions using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Use pot spacing of 2 inches (CP303) for easy picking. Plant when the scallions have developed enough root system to hold onto the pot but not until they start branching out into other pots. Slightly bury the plants and make sure the pots themselves are fully covered to avoid drying out. Irrigate the first week until roots are established.
- Using paper pots is also a means to avoid transplant shock, as scallion roots don't hold the pot together

well in a cell pack.

Transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
3	5 inches	Not too deep; the same level as the potting medium and a little below	Use a 5-inch sprocket.

Cultivation procedures

- Prepare seed beds 1–2 weeks in advance. If possible, shallowly stale seedbed before planting to eradicate weeds. Don't disturb the soil too deeply, as this can bring up new weed seeds.
- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.
- Use finger weeders or spring hoes in combination with side knives for a second cultivation. These tools effectively eliminate small weeds.

Frost, disease and insect protection

- Watch for onion thrips, and control with a spinosyn-based product, such as Entrust, or *Beauveria bassiana*, as in the product Mycotrol ESO. With *Beauveria bassiana* you'll see results after a week of applying. Alternatively, use a mineral oil like JMS Stylet-Oil. Repeat applications of the selected product every 5–7 days. Don't exceed the maximum rate of 3 applications per season for Entrust. As direct contact with the pest is required for all these products, only spray at night, as thrips are nocturnal. Act when pest pressure is still low.
- Purple blotch (*Alternaria porri*) occurs mostly in the summer under wet and humid conditions. Plants that are weakened by thrips are more susceptible to this disease. Keeping the crop weed free to allow for air circulation, planting long rotations, practicing good sanitation (e.g., removing or incorporating diseased plant material) and avoiding excessive N are good preventive measures.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Follow scallions with another short season cash crop like lettuce, spinach, arugula or radishes, or plant a cover crop.

Spinach

Spinacia oleracea (*Chenopodiaceae* or goosefoot family)

Soil preparation

- Total nutrient uptake is 100 lbs. of N, 12 lbs. of P and 100 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Incorporate compost and plant spinach in raised beds.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like spinach don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Direct-seeded spinach requires a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date, depending on the time of year. This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
125	0–170	0–200	6.5–6.7

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Massachusetts overwintered spinach variety trial
- Washington State variety trial
- Some popular varieties are Space (disease resistant, good for all season), Equinox (for spring and fall), Kolibri (all season, good for baby size), Gazelle (for winter production) and Reflect (for heat resistance).

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	5	50	20	2–4		Mix with a biocontrol to avoid damping off.
Sutton Jr.	9	25	18	¼–½		0.8 mph
Jang	5	24	F24		Front 14/rear 9 or 10	

Transplanting and direct seeding tips

- You can transplant spinach using a paper-pot planter, which allows you to get optimum spacing and an early start. Start paper pots in the greenhouse. This results in a high germination rate. Use a pot spacing of 2 inches (CP303) for easy picking. Plant when the spinach has developed its first true leaves. Planting later leads to transplant shock. Don't bury the plants, but make sure the pots themselves are covered to avoid drying out. Irrigate until roots are established.
- If damping off is an issue, add a biocontrol to the planter box. *Trichoderma harzianum* (as in T22) or *Streptomyces iydicus* (as in Actinovate or Micro 108) provide some efficacy.

Number of successions

- Start your earliest spring spinach in paper pots 7–10 days before you plant them in the field.
- When you transplant the paper pots, direct seed the next succession.

- For continuous harvest, plant another succession once the previous succession has developed its cotyledons. Stop seeding when the expected harvest date—which is 45–55 days from seeding—falls during summer heat. This is around mid-May in New York.
- Start planting spinach again when the expected harvest date falls at a time when the weather will cool off. This is around July 14 in New York.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand weed as needed.

Frost, disease and insect protection

- For white rust, select resistant or tolerant varieties. Leaf miners can be a serious issue with spinach. Use row covers or insect netting to prevent the adult fly from laying its eggs on crops. If row covers or insect netting aren't an option, place yellow sticky cards at plant height and check at least twice a week for adults that look like a fly, or look on the underside of the leaves for the presence of eggs. In the northern United States there are generally 3 generations of adult flies laying eggs. Once the eggs hatch ,or when you see the first signs of damage, apply a spinosyn-based product like Entrust every 5–7 days, not to exceed 3 sprays.
- To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 2 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Spinach rotates well either before or after other short-season vegetables like lettuce, mustard greens, arugula and radishes.

Additional resources

- Organic Production and IPM Guide for Spinach

Squash, Summer (Including Zucchini)

Cucurbita pepo (*Cucurbiticeae* or cucumber family)

Soil preparation

- Summer squash should not follow after other cucurbits or nightshades, but it follows well after cole crops and leguminous green manures or sweet corn.
- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost and plant summer squash in raised beds covered with or without plastic mulch.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New Hampshire variety trial
- North Carolina zucchini and summer squash variety trial
- Dunja, Spineless Perfection and Green Machine are popular among organic growers. Multipick, Slickpick and Smooth Operator are popular as summer squash varieties.

Greenhouse guidelines

- EZ Seeder seeding plate #5
- Early in the season, germinate seeds in a germination chamber unless you can keep the greenhouse warm both day and night. Germination improves greatly at optimum temperatures.
- Use a 1020 tray with 24 pots for more light, resulting in stockier plants. When using a 38-pot tray, make sure you transplant before they get leggy.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	75°	75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take outside 1 week before planting in the field.

Number of successions

- Seed summer squash and zucchini 3 weeks before you transplant in the field. If you aren't able to maintain a healthy plant throughout the summer, repeat another planting after about a month. Plants will start to drop productivity due to a lack of nutrients and increased disease and insect pressure.

Signs to watch for and what to do

- Summer squash grows fast. Make sure plants can go in the field without becoming leggy because leggy plants suffer and can perish in the summer heat.
- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they can't, their roots will be damaged and the plants have a higher fatality rate.

Transplanting tips (when using plastic mulch)

- Avoid laying plastic mulch after crops that leave a lot of residue on the surface, such as cabbage or corn stalks. When establishing an early cover crop of oats and peas before plasticulture, mow it before the winter to avoid clogging up the plastic mulch layer in the spring.

- For the first planting, use infrared transmitting (IRT) plastic because it helps warm the soil.
- Lay plastic mulch at least a week before planting to allow weed seeds to germinate and the soil to warm. Planting on the same day as laying the plastic will cause weed pressure in the planting hole.
- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.
- To help resist striped cucumber beetle damage, dissolve Kaolin clay (as in Surround) in plenty of water and drench the complete tray in the solution before transplanting.
- The following tip is useful when you have harvest lanes, where every 8 or 10 beds are separated by a grass strip: Mark a 4-foot "walking break" on the plastic mulch every hundred feet and don't plant anything in that 4-foot strip. This will make harvesting easier by allowing you to easily pass through the crop when removing buckets. Instead of carrying the buckets of squash to the headland, one can walk through the crop (instead of over) to the left or right and place the buckets in the harvest lane to be collected by truck or other vehicle.

Water wheel planter

Rows	In-row spacing	Planting depth (inches)	Notes
1	12 inches	Same level as the potting medium	Add kelp to water as a 0.5% solution in the water wheel planter.

Cultivation procedures (without plasticulture)

- If growing squash in the traditional bed system, you can use your regular cultivation setup with side knives reconfigured for a one-row system. Don't use any finger weeders. Precision cultivation can damage cucurbits, so keep a good distance from the crop to avoid damage.
- Hand hoe between plants.

Cultivation procedures (with plasticulture)

- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass, because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Plant early plantings downwind from later varieties, as both powdery and downy mildew are windborne.
- For your earliest plantings, use floating row covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If you don't need frost protection or a warm environment, you can use the longer-lasting insect covers to provide protection against beetles.
- Squash bug populations can be kept under control by rotating far from where you grew squash the previous year. Unfortunately, squash bugs shelter in the straw that's between plastic mulch.
- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis*, as in CEASE, and potassium bicarbonate, as in MilStop SP. Sulfur causes phytotoxicity in squash, so be careful if you're applying sulfur in any form to control powdery mildew. Also, consider using tolerant or resistant varieties.
- Downy mildew can be somewhat controlled with the biological control *Pseudomonas aeruginosa*, as in Zonix. Also, consider using tolerant or resistant varieties.
- A full list of OMRI-listed control products on cucurbits, along with their efficacy, is available from CALS.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation,

precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Incorporate any remaining plants, weeds and fruit into the soil, and plant a cover crop like rye and vetch. This will reduce the squash bug population.
- If weed pressure was high and caused a lot of seed rain, it's better to refrain from any fall tillage. Instead, allow the weed seeds to decay and be eaten by birds and rodents over the winter months to reduce future weed pressure. Unfortunately, this is contradictory to keeping the squash bug population under control.

Squash, Winter

Cucurbita pepo (Acorn, Spaghetti, Delicata)
Cucurbita maxima (Kabocha, Hubbard)
Cucurbita moschata (Butternut)
(*Cucurbiticeae* or cucumber family)

Soil preparation

- Winter squash should not follow after other cucurbits or nightshades, but it follows well after cole crops and leguminous green manure or sweet corn.
- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- Incorporate compost and plant winter squash in raised beds or on flat ground, with or without plastic mulch.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State, Oregon, Wisconsin and Minnesota variety trial
- New York variety trial
- Honeynut, Delicata, Bon Bon, Chieftain butternut, Royal Ace acorn, Sunshine, Red Kuri, Baby butternut, and Spaghetti are popular winter squash varieties amongst growers.

Greenhouse guidelines

- EZ Seeder seeding plate #5 or seeded by hand
- Use a 1020 tray with 24 pots for more light, which results in stockier plants. When using a 38-pot tray, make sure you transplant before they get leggy.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 28	75°	75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take outside 1 week before planting in the field.

Signs to watch for and what to do

- Winter squash grows fast. Make sure to transplant into the field before they get leggy.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they can't, their roots will be damaged and the plants have a higher fatality rate.

Transplanting tips

- Lay plastic mulch at least 1 week before planting to allow weed seeds to germinate and the soil to warm. Planting on the same day as laying the plastic will cause weed pressure in the planting hole.
- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky

transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.

- To help resist cucumber beetle damage, dissolve Kaolin clay (as in Surround) in plenty of water and drench the complete tray in the solution before transplanting.

Water wheel planter

Rows	In-row spacing	Planting depth (inches)	Notes
1	12 inches	Same level as potting medium	Add kelp to water as a 0.5% solution in the water wheel planter.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
MaterMacc	1	1	9 H 4.5	½	22-18	

Cultivation procedures (without plasticulture)

- If you didn't plant winter squash through plastic mulch, eliminate weeds when they're in the white thread stage. The choice of tools depends on row distance.
    - You can use your regular cultivation setup with side knives if growing squash in the traditional bed system. Don't use any finger weeders. Precision cultivation can damage cucurbits. Keep some distance from the plants to avoid this.
    - You can use a regular field cultivator and drive between rows if you planted the squash 10–12 feet apart.
    - In both cases, hand hoe between plants.

Cultivation procedures (with plasticulture)

- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Plant early plantings downwind from later varieties, as both powdery and downy mildew are windborne.
- For your earliest plantings, use floating row covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If you don't need frost protection or a warm environment, you can use the longer-lasting insect covers to provide protection against beetles.
- Squash bug populations can be kept under control by rotating far from where you grew squash the previous year. Unfortunately, squash bugs shelter in the straw that's between plastic mulch.
- Powdery mildew: The best way to avoid losses from powdery mildew is to use tolerant or resistant varieties. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis*, as in CEASE, and potassium bicarbonate, as in MilStop SP. Sulfur causes phytotoxicity in squash, so be careful if you're applying sulfur in any form to control powdery mildew. Also, consider using tolerant or resistant varieties.
- Downy mildew can be somewhat controlled with the biological control *Pseudomonas aeruginosa*, as in Zonix. Also, consider using tolerant or resistant varieties.
- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- A full list of OMRI-listed control products on cucurbits, along with their efficacy, is available from CALS.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Incorporate any remaining plants, weeds and fruit into the soil, and plant a cover crop like rye and vetch. This will reduce the squash bug population.
- If weed pressure was high and caused a lot of seed rain, it's better to refrain from any fall tillage. Allow the weed seeds to decay and be eaten by birds and rodents over the winter months to reduce future weed pressure. Unfortunately, this is contradictory to keeping squash bug populations under control.

Additional resources

- Organic Production and IPM Guide for Cucumbers and Squash
- Pumpkin and Squash Fertility Management

Sweet Potatoes

Ipomoea batatas (*Convolvulaceae* or morningglory family)

Soil preparation

- Total nutrient uptake is 140 lbs. of N, 20 lbs. of P and 200 lbs. of K.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Sweet potatoes don't do well when nitrogen is applied before planting. Instead, using a slow-release compost like feather meal is advisable.
- Incorporate compost and plant sweet potatoes on high raised beds covered with plastic mulch, or on ridges.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
75	0–300	0–350	5.0–6.8

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- New Hampshire variety trial
- Sweet potato varieties released by North Carolina State University
- Plants are bought as bare-root slips.
- Covington and Baueregard are popular varieties. Select Murasaki when you want a purple sweet potato with white flesh.

Transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
2 rows, 30–36 inches apart	12 inches	Plant deep for the highest yield. All roots should be firmly underground without burying the growing point.	Plant the slips immediately after receiving them. Don't store them in a cooler or set them in water. Irrigate after planting. The distance between rows is based on wheel track spacing.

Transplanting tips

- In-row spacing should be a maximum of 12 inches because sweet potatoes do better with closer spacing.

Cultivation procedures (without plasticulture)

- Use a tine weeder for the first cultivation, but make sure plants are firmly rooted first.
- For all other cultivations, continue to hill up the sweet potatoes without burying the plants.
- Make several passes and remove any remaining weeds by hand.

Cultivation procedures (with plasticulture)

- Cultivate twice in between plastic with a rolling cultivator or Spyder to control weeds**.**
- Don't cover the wheel tracks with rye straw because such a cover can attract field mice and voles that will damage the crop.
- Instead, vines will quickly cover the wheel tracks to provide weed control.

Deer, disease and insect protection

- Check the soil for wireworms, as a high population can make sweet potatoes unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Promising results have also been obtained applying *Beauveria bassiana*.
- Deer can do extensive damage to sweet potatoes, as it's one of their favorite crops. To prevent deer damage, build a temporary fence using 4-foot fiberglass posts and attach 1 clearly visible wire like IntelliTape at about knee height. Build a second fence inside the first fence, but attach 2 wires or twine whereby the top line is about 7-feet tall. Deer don't have very good depth perception and won't attempt to jump this fence without checking out the first fence, so electrifying the second fence is often not needed. Bait the outside deer fence with peanut butter and electrify it. Make sure you build the fences, bait and electrify on the same day. The surprise effect is what matters most with this particular deer control.
- Mow foliage and harvest tubers before the soil temperature dips below 60˚.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- A cover crop of rye and hairy vetch usually follows sweet potatoes.

Additional resources

- North Carolina Organic Sweet Potato Production
- Cornell University: Considerations when planting sweet potatoes

Tatsoi

Brassica rapa (*narinosa group*) (*Brassicaceae* or cabbage family)

Soil preparation

- Tatsoi should not follow after other cole crops.
- A soil test will determine how much compost needs to be applied.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Direct-seeded tatsoi requires a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date (depending on the time of year). This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
120	0–160	0–200	6.2–6.5

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Greenhouse guidelines

- EZ Seeder seeding plate #16

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
128	65°–75°	65°–75°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Number of successions

- Spring: Tatsoi doesn't do well during hot and dry weather. Plant it in the greenhouse 4–5 weeks before the last frost date. Depending on your markets, plant each week for continuous harvest in spring and early summer. In New York, this is limited to 2–3 successions.
- Fall: Tatsoi does best as a fall crop. In New York, seeding or planting is resumed in July on a weekly basis until 4–5 weeks before the first frost, for continuous harvest until November.

Transplant readiness indicators

- Plants should come out of their cells easily. Plants should generally not be older than 5 weeks.

Transplanter

Rows	In-row spacing	Planting depth	Notes
3	5 inches	Normal: The potting medium should be level with the soil.	Water wheel planters can only plant as close as 7 inches, so adjust the in-row distance as needed.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3–5	22	2	Depth 2		Spreader shoe
Sutton Jr.	9	30	6	¼		1 mph
Jang	3–5	6	YYJ 12 or YX12		Front 14/rear 9 or 10	

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Hand hoe between plants.

Insect and disease protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence or after transplanting to avoid flea beetle damage. Keep covered until harvest. Or, use a spinosyn-based product like Entrust.
    - Fall-planted tatsoi doesn't need any protection after the third generation of flea beetles, which is around September 1 in the Northeast. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce infestations of cabbage maggots on young seedlings, cover them with floating row covers or insect netting, as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant fall lettuce or spinach after early-planted tatsoi.
- You can follow a late tatsoi crop with a cover crop, but don't incorporate the residue when harvesting in November. This is to avoid winter erosion.

Tomatoes

Solanum lycopersicum (*Solanaceae* or nightshade family)

Soil preparation

- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Total nutrient uptake is 180 lbs. of N, 21 lbs. of P and 280 lbs. of K.
- A soil test will determine how much compost to apply.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- A fertilizer company can add OMRI-listed potassium sulfate to compost if it doesn't have enough K to meet the crop's needs. If this isn't possible, spread the correct amount of fertilizer and incorporate it before planting.
- Most vegetable crops remove little P, but at times your soil test result will call for additional P. Unfortunately, there aren't short-term options for an organic grower to increase the available P levels in the soil. Through the use of animal-based fertilizers, P will build up to a level in the soil that is sufficient for all vegetable crops.
- Incorporate compost and plant tomatoes on high raised beds covered with plastic mulch.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–200	0–240	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New York variety trial
- Wisconsin variety trial
- Popular with growers
    - Early red: Polbig, Early Cascade (Alternaria tolerant), Early Girl, New Girl, Fourth of July
    - Midseason red: Celebrity (sweet and good disease tolerance), Tastilee
    - Late red: Mountain Fresh Plus, Mountain Merit (Alternaria resistant)
    - Small plum: Juliet (high disease resistance and great flavor), Golden Rave
    - Large cherry: Mountain Magic (excellent disease resistance)
    - Cherry tomato: Sungold, Superweet 100, Sakura, Edox, Valentine
    - Heirloom: Valencia, Nepal, Brandywine
    - Plum: Plum Regal, San Marzano

Greenhouse guidelines

- EZ Seeder seeding plate #16
- Early in the season, germinate seeds in a germination chamber unless you can keep the greenhouse warm both day and night. Germination improves greatly at optimum temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
288	75°–90°	60°–70°	Withhold water	Put plug trays on a wire mesh bench to encourage air pruning. Take plants outside 1 week before planting in the field.

Number of successions

- This depends on the grower and the type of tomato.

- Indeterminate tomatoes produce all season long. If you can keep them disease free and well fed, there is no need for a succession.
- Additional planting may be a good strategy for harvesting disease-free tomatoes late in the fall. In that case, start a determinate or semi-indeterminate tomato variety 5 months before the first frost date. (This is the middle of May in New York.)

Greenhouse guidelines

- Repot into 38- or 50-cell trays, or into 4-inch pots, when true leaves are developed.
- To reduce elongated growth in seedlings, brush plants with a broom at least once a week to get stocky seedlings. Dr. Joyce Latimer of Virginia Cooperative Extension found that this type of mechanical stimulation is an effective way to prevent excessive stem elongation (stretching). Brush across the top of the canopy in long gentle strokes with a broom, preferably one that is unpainted because leaves won't stick to it. Begin this treatment when the plants are about 2.5-inches tall. Run the broom about ½–1 inch below the top of the canopy to lean the plants over gently, 10 times back and forth, once a day. In mid-June it takes 20 strokes. More treatment than that can damage the leaves. If you see damage, it's too much! Brush when the foliage is dry but the plants aren't wilted. Mostly, this will be before watering in the morning.

Transplant readiness indicators

- Transplant when plants have enough of a root ball to hold the pot together. Plants that are lush don't perform well in the field when hardening off, so increase light by moving them outside and reduce watering.

Water wheel planter

Rows	In-row spacing	Planting depth	Notes
1	24 inches	As deep as possible	Add kelp to water as a 0.5% solution in the water wheel planter.

Transplant tips

- The first planting should be on infrared transmitting (IRT) plastic, while the second and third plantings can be on black plastic or bare ground.
- The following tip is useful when you have harvest lanes, where every 8 or 10 beds are separated by a grass strip: Mark a 4-foot "walking break" on the plastic mulch every hundred feet and don't plant anything in that 4-foot strip. This will make harvesting easier by allowing you to easily pass through the crop when removing buckets. Instead of carrying the buckets of tomatoes to the headland, one can walk through the crop (instead of over) to the left or right and place the buckets in the harvest lane to be collected by truck or other vehicle.

Cultivation procedures (with plasticulture)

- After transplanting, cultivate once or twice between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Cultivation procedures (without plasticulture)

- Ideally, control weeds when they're in the white thread stage. When using precision cultivation tools, make sure plants are established and won't be uprooted by the use of close implements.
- When plants aren't established, use side knives or sweeps only.
- When plants are established, use a finger weeder in combination with side knives for best weed control. Alternatively, if you want very slight hilling, use spring hoes in combination with side knives.

- Hand hoe or hand weed between plants.

Training and pruning tomatoes

- When using determinate or semi-determinate varieties, prune off all the suckers, up to the 1 immediately below the first flower cluster. Don't remove the sucker below the first flower cluster or any that are above it. Doing so can cause severe stunting. Some varieties may do better with leaving the 2 suckers below the first flower cluster. It's better to leave too many suckers than to remove too many. Try to remove them when the suckers are 2–4 inches long. Prune before the first stringing and only when the plants are dry to avoid spreading bacterial diseases. You may have to go back and prune a second time. For more detail, read this article by Rutgers University.
- Use 5-foot stakes and T posts for semi-indeterminate varieties (such as Mountain Spring or Fresh), and 4-foot stakes and T posts for determinate varieties (such as Defiance or Regal Plum). Use a handheld fence post driver to pound in the stakes and T posts every other plant (4-feet apart). Drive them about 12–18 inches deep, and be careful to avoid puncturing drip tape.
- Here is a video describing how to apply the tomato twine. Use tomato twine that comes in a cardboard box. The plants will need to be "strung" for the first time when they're about 8–10 inches tall. Make sure you get to them before they flop over. Use a homemade stringing tool to make tying convenient. The tool will work as an extension of your arm, limiting the amount of bending you'll need to do. Take an old broom handle, about 2-feet long, and drill 2 holes 1 inch from each end, and feed the string through both holes. Alternatively, use a PVC pipe of the same length, except drill only 1 hole about 8 inches from the bottom, and feed the string through the hole and the pipe. Either method keeps tension on the string while you work. Attach the box of string to your belt and thread the twine through the tool. Tie the end of the string to the first stake, about 10 inches above ground level. You are now ready to weave.
- Use the stringing tool to pass string along the near side of the first tomato plant and the far side of the second. Your other hand can help provide the right amount of tension. As you get to the second stake, wrap the string tightly around the stake 1 or 2 times, and continue down the row in the same manner. When you reach the last stake in the row, work your way back down the row in a similar manner, but make sure you're wrapping the twine around the opposite side of each plant, in a figure-eight manner, so that each plant is held firmly in place. When you get back to where you began, tie the string on the first stake.
- Repeat this procedure as the plants grow, placing strings about every 10 inches. Simply run the string down 1 side of the plants and up the other side when you return. That will leave you with about 4–5 strings for a determinate plant and more when using semi-determinate plants.

Frost, disease and insect protection

- Staking greatly improves plant health, and a thick mulch of rye straw also reduces plant diseases. While it won't prevent a late blight (*Phytophthora*) outbreak, the practice of using tolerant or resistant varieties in combination with plastic mulch and heavy rye straw mulch greatly reduces disease pressure. Plant any additional successions in different parts of the field to avoid the spread of disease, and plant each succession away from the prevailing wind (west).
- When late blight (*Phytophthora*), early blight (*Alternaria*), gray mold (*Cladosporium*), leaf spot (*Septoria*) or bacterial speck is a problem, use a weekly spray of an OMRI-listed copper, as in Nordox 75 (CuO) or Nu-Cop50 (CuOH). Mix it with a spreader/sticker for a longer effect. Alternatively, use a mineral oil as in JMS Stylet-Oil to replace the spreader/sticker, but don't use both, as this can cause crop damage. Regular applications of a giant knotweed extract (R*eynoutria sachalinensis*), as in the product Regalia, provides the plant with greater resistance against plant diseases.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- Remove stings, stakes, plastic and drip tape shortly after the last harvest.
- Work under any harvest and mulch remains to avoid insect or pathogen buildup, and plant a cover crop.

- In the northern United States and Canada, you can plant oats and peas after early tomatoes, or rye and vetch after later tomatoes. Adjust accordingly in other regions.
- Clean and sanitize the stakes before storage. Use an OMRI-listed chlorine or hydrogen peroxide solution. Plant pathogens will continue to survive on soil particles left on the stakes.

Tomatoes, High Tunnel

Solanum lycopersicum (*Solanaceae* or nightshade family)

For more production information see the main Tomato section, as many of the cultural practices apply to high-tunnel production.

Soil preparation

- Total nutrient uptake is usually higher than field tomatoes.
- A soil test will determine how much compost to apply.
- Incorporate compost and plant tomatoes in raised beds.
- High tunnels are known to accumulate P over time. Be careful when applying animal-based fertilizer that contains a significant amount of P.
- Be careful when using plant-based fertilizers like peanut meal as a source for N. Some growers have lost their crop due to pathogens and nematodes present in plant-based fertilizers.

Varieties

- Comparing tomato varieties in high tunnel and open field conditions in the Midwest
- Illinois variety trial
- Iowa variety trial

Greenhouse guidelines

- Many high-tunnel producers graft their plants on disease-resistant rootstock to improve plant health. Here's an excellent video on grafting tomatoes.

Planting by hand

Rows	In-row spacing	Planting depth (inches)	Notes
1	12–24 inches	As deep as possible	Plants have 1 or 2 leaders. When plants have 2 leaders they are set at 24 inches, giving each leader 12 inches. Rows are generally 4–5 feet apart.

Number of successions

- Only 1, when growing the tomatoes as a single or double leader.
- Some growers plant a determinate tomato variety for very early production and another determinate variety for late production to avoid low market prices in August.

Trellising

- You can still grow determinate varieties with the traditional Florida weave system, as described in the Tomato section.
- Indeterminate varieties are trained to 1–2 leaders with a string trellising system:
  - Decide 1 or 2 leaders per plant. Two leaders are easier to manage, but many varieties do better as a single leader. One consideration is the cost of grafting and seed. You save some time and resources by choosing 2 leaders.
  - Use an in-row spacing of 12 inches for single leaders and 24 inches for 2 leaders.
  - Drop a line down from the overhead support, 1 line for each leader. Use the same twine that you use for the Florida weaving system.
  - Use a tomato clip to fasten the line below the first leaves. After that you can wrap the line clockwise around the stem as you train the plant.
  - For a double leader, establish a strong Y by removing the leaves up to the first flower cluster. Leave the sucker just under the first flower cluster and remove all suckers below that point. The stem should now look like the letter 'Y'. Each arm of the Y will become a leader.
  - Maintain the leaders throughout the growing season by continually pruning off all suckers. You'll need

to prune on at least a weekly basis. It's best to prune during the morning hours after any dew has dried off. Remove suckers when they're small to avoid plant damage.

Frost, disease and insect protection

- Growing tomatoes in a tunnel greatly improves plant health. While you may avoid late blight, other diseases like powdery mildew, leaf molds (*Fulvia*), and Septoria leaf spot, and *Sclerotinia* (timber rot) and *Botrytis* can become an issue. The practice of planting or grafting tolerant or resistant varieties in combination with good sanitary practices greatly reduces disease pressure. Pruning and good air circulation are primary defenses against foliar problems. Powdery mildew is partially controlled through genetics, but weekly foliar sprays of potassium bicarbonate, as in MilStop SP, have also proven to be effective.
- Tomato hornworms can be an issue in high-tunnel production. You can either pick them off plants or spray with *Bt aizawai*, as in the product XenTari.
- Two spotted spider mites can best be controlled by introducing a predatory spider mite. Spraying neem oil or JMS Stylet-Oil can be effective, but isn't advisable as it leaves a residue on the tomatoes.
- Aphids: Check for aphids using yellow sticky cards. As aphids can spread viral diseases, control them when present by introduction of beneficials like green lacewings. At high populations, use *Beauveria bassiana*, as in the product Mycotrol ESO, for effective control.

Monitoring nutrients

- Due to the much higher production of tomatoes in a high-tunnel, the crop might need additional fertilizer throughout the season. Obtain a plant tissue analysis from a commercial lab to establish any deficiencies.
- If a tissue analysis determines plants need additional fertilizer—either N or K—you can adjust by injecting the corresponding liquid fertilizer through a drip line.

Additional resources

- Cornell University: Tomatoes in High Tunnels

Turnips

Brassica rapa (*Brassicaceae* or cabbage family)

Soil preparation

- Turnips should follow after other cole crops.
- A soil test will determine how much compost to apply.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- If compost does not contain enough K, it can be added by the fertilizer company in the form of potassium sulfate.
- Test for boron and apply only as recommended by the soil test. A fertilizer company can add boron to compost to optimize boron distribution. If this isn't an option, distribute soluble boron through a water solution with a sprayer directly on the soil. If applied directly on the crop, don't exceed more than 1 lb. of boron per acre to avoid leaf burn.
- Plant turnips in raised beds.
- Jang, Sutton Jr. or Planet Jr. planters in combination with small seeds like turnips don't perform well with plant matter on the soil surface, so avoid planting them after tall green manures.
- Turnips require a fine and firm seedbed. Prepare the land a few weeks in advance to provide the opportunity for some initial weed control via shallow cultivation or flaming.
- Alternatively, place a silage tarp over the prepared and irrigated seedbed 3–5 weeks in advance of the seeding date (depending on the time of year). This will flush many annual weed seeds and reduce weed pressure. Remove the tarp when the weeds have died.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
60	0–125	0–200	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- New Jersey variety trial
- Hakurei or Tokyo market are good for bunched turnips.
- Purple Top White Globe is good for winter storage.

Direct seeding information

Seeder	Rows	Seeds per foot	Seed plate no.	Depth (inches)	Sprocket setting	Notes
Planet Jr.	3	35	1–2	Depth 2		Only use a regular shoe.
MaterMacc	3	12	96 H 1.0	¼–½	See Notes.	Sprocket 22-17 for storage turnips
Jang	3	12–24	YX 24 or YYJ 24		See Notes.	Sprocket: Front 14/rear 10 for bunched turnips; Front 10/rear 13 for storage turnips

Number of successions

- Spring: Avoid growing turnips during hot and dry weather. Plant turnips as one of your earliest crops in the field. Depending on your markets, plant each week for continuous harvest from spring into early summer. This is limited to 2–3 successions in New York.
- Fall: Turnips perform well as a fall crop. In New York, we resume seeding or planting in August on a weekly

basis, and stop 4–5 weeks before the first frost. This gives a continuous harvest until November. Don't plant storage turnips before mid-August, or they can get oversized.

Cultivation procedures

- Use a basket weeder or wheel hoe when weeds are in the white thread stage, without burying the young crop. Weed control is more effective when you eliminate weeds before they emerge.
- Use spring hoes in combination with side knives for a second cultivation.
- Hand weeding isn't always needed, as turnips grow quickly and shade out in-row weeds.

Insect protection

- Control black rot (*Xanthomonas*) by purchasing clean seeds, keeping the greenhouse clean and exposing seed to hot water treatment. Some organic seed suppliers hot treat their seeds, so check with them before applying your own treatment, as double treatment can affect germination.
- Flea beetles
    - Cover the crop with floating row covers or insect netting before emergence to avoid flea beetle damage. Keep covered until harvest. Alternatively, use a spinosyn-based product like Entrust.
    - Fall-planted turnips don't need any protection after the third generation of flea beetles, which is around September 1 in the Northeast. If possible, follow Extension bulletins that publish the timing of each generation of flea beetles, or place yellow sticky cards at plant height to monitor their presence. Check the cards at least twice a week.
    - Spray beneficial nematodes on heavily infected land to control flea beetle grubs and to avoid future generations. Flea beetles tend to overwinter in nearby hedgerows and grass strips.
- Scout for the eggs of imported cabbage worms or diamondback moths on the underside of leaves. When the small-worm population is over 2 per plant, spray a *Bacillus thuringiensis* (*Bt aizawai* or *Bt kurstaki*) product, such as XenTari, or a spinosyn-based product, such as Entrust, every week until the population is under control. Alternate your spraying schedule by using Bt products along with a spinosyn-based product to avoid resistance buildup.
- Check the soil for wireworms, as a high population can make turnips unmarketable. To avoid wireworm damage, rotate with crops like onions, lettuce or alfalfa, or include buckwheat as a cover crop the previous year. Some results have been obtained using beneficial entomopathogenic nematodes. Promising results have also been obtained applying *Beauveria bassiana*.
- You can prevent cutworms by spraying the soil with the beneficial nematode *Steinernema carpocapsae*. Once the pest is in the crop, control the population by spraying the crop with *Bacillus thuringiensis kurstaki*, or spread a baited product containing spinosyn, like Seduce, around the plants.
- Cabbage maggots: To reduce cabbage maggot infestations on young seedlings, cover them with floating row covers or insect netting, as you would for flea beetles. Maggots appear in 3–4 generations in the Northeast, starting in early spring.

Other cultural practices

- Irrigate frequently for optimum yield and plant health. Frequency depends on soil type, evaporation, precipitation and the particular needs of the crop.

Double cropping and/or cover cropping

- You can plant fall lettuce or spinach after early-planted turnips.
- You can follow a late turnip crop with a cover crop, but don't incorporate the residue when harvesting in November. This is to avoid winter erosion.

Watermelons

Citrullus lanatus (*lanatus* variety) (*Cucurbitaceae* or cucumber family)

Soil preparation

- Watermelons should not follow after other cucurbits or nightshades, but they follow well after cole crops, leguminous green manures or sweet corn.
- Where *Phytophthora* (*Phytophthora capsici*) is an issue, rotate away from this land. Biofumigation has shown some effectiveness to reduce incidences.
- Apply compost and other amendments based on the results of a soil test.
- Spread lime as needed to increase both the pH and Ca levels. Dolomite lime will also increase Mg levels. Spread gypsum when calcium levels are low but pH is correct.
- In northern regions, plant watermelons in high raised beds covered with plastic mulch for the best results.

Common recommended fertilizer rates[1]

Nitrogen	Phosphorus	Potassium	pH
100	0–160	0–160	6.0–6.4

[1]Rates are for New York and are from Cornell University's *Nutrient Guidelines for Commercial Vegetable Production* (2019). Check the Cornell website for updated guidelines, or consult with local experts for recommended rates outside New York.

Varieties

- Washington State variety trial

Greenhouse guidelines

- EZ Seeder seeding plate #5
- Use a 1020 tray with 24 pots for more light, which results in stockier plants. When using a 38-pot tray make sure you transplant before they get leggy.
- Start seeds in the germination chamber or when you can keep your greenhouse warm both day and night. Germination is poor at lower temperatures.

Cell pack tray	Germination temp	Growth temp	Hardening off	Notes
24 or 38	80°–90°	85°	Less water and a lower temperature for 1 week	Place plug trays on a wire mesh bench to encourage air pruning.

Number of successions

- Start seedlings 3 weeks before the last frost date.
- For continuous harvest, plant the next successions on a 10–14 day schedule until 2 ½ months before the first frost.

Signs to watch for and what to do

- Watermelon plants like to grow under warm conditions, which isn't always compatible with other vegetables grown simultaneously. Find the warmest spot in your greenhouse for them.

Transplant readiness indicators

- Harden plants off outside; plants that are lush don't perform well in the field.
- Transplant in the field when plants have enough of a root ball to hold the soil in the pot or cell pack together. When they can't, their roots will be damaged and the plants have a higher fatality rate.

Transplant tips

- Lay plastic mulch at least 1 week before planting to allow weed seeds to germinate and the soil to warm. Planting on the same day as laying plastic will cause weed pressure in the planting hole.

- Avoid transplanting in plastic mulch during the heat of a hot summer day. The heat of the plastic can cause damage to the young seedlings. To avoid burning the young plants, transplant in the evening, use stocky transplants and water deeply. If planting by hand, water plants with a watering can. Avoid applying row covers in hot conditions. When hot weather is expected after transplanting, only use insect cover for protection.
- To help resist striped cucumber beetle damage, dissolve Kaolin clay (as in Surround) in plenty of water and drench the complete tray in the solution before transplanting.

Water wheel transplanter

Rows	In-row spacing	Planting depth (inches)	Notes
1	12 inches	Normal	Add kelp to water as a 0.5% solution in the water wheel planter.

Cultivation procedures

- As watermelons are a tropical fruit, use infrared transmitting (IRT) plastic for your first planting because it helps warm up the soil.
- After transplanting, cultivate once or twice in between plastic with a rolling cultivator or Spyder. Cover the wheel tracks with rye straw at a rate of 3 lbs. per foot. (One 600 lb. round bale covers 200 feet of wheel track.) Increase this amount when using an early cutting of orchard grass, because hay breaks down much faster than straw. Over time, hay and straw mulch will release a significant amount of K and other beneficial properties like silicon, contributing to long-term soil health. Mulching also protects crops from soil splashing. This reduces soilborne diseases and time spent cleaning produce after harvest.

Frost, disease and insect protection

- Plant early plantings downwind from later varieties, as both powdery and downy mildew are windborne.
- For your earliest plantings, use floating row covers to protect against frost and striped cucumber beetles. For varieties that require pollination, remove the covers at flowering. Use 10-gauge wire to support the row cover, since abrasion against the cover will damage the plants. If you don't need frost protection or a warm environment, you can use the longer lasting insect covers to provide protection against beetles.
- Powdery mildew: While powdery mildew is not common in watermelons, it's an emerging issue and therefore discussed here. Powdery mildew can be somewhat controlled with a mixture of *Bacillus subtilis*, as in the product CEASE, and potassium bicarbonate, as in MilStop SP. Sulfur causes phytotoxicity in melons, so be careful if you're applying sulfur in any form to control powdery mildew. Also, consider using tolerant or resistant varieties.
- Downy mildew can be somewhat controlled with the biological *Pseudomonas aeruginosa*, such as the product Zonix.
- A full list of OMRI-listed control products on cucurbits, and their efficacy, is available from CALS.