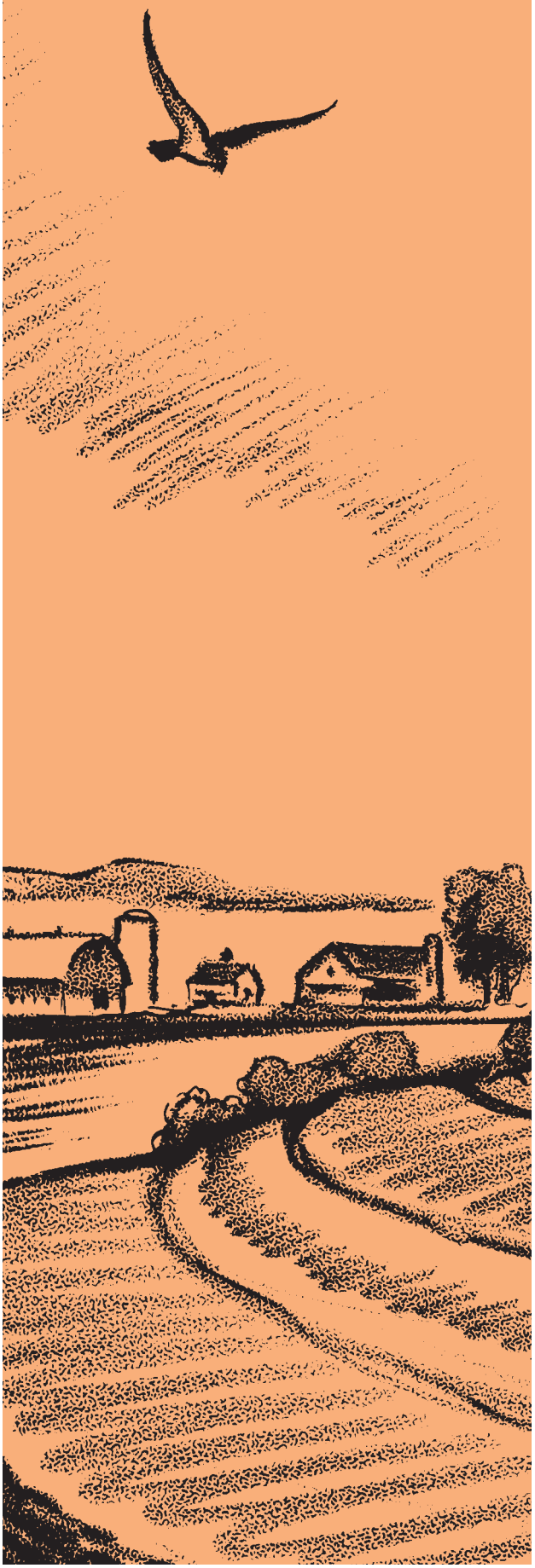
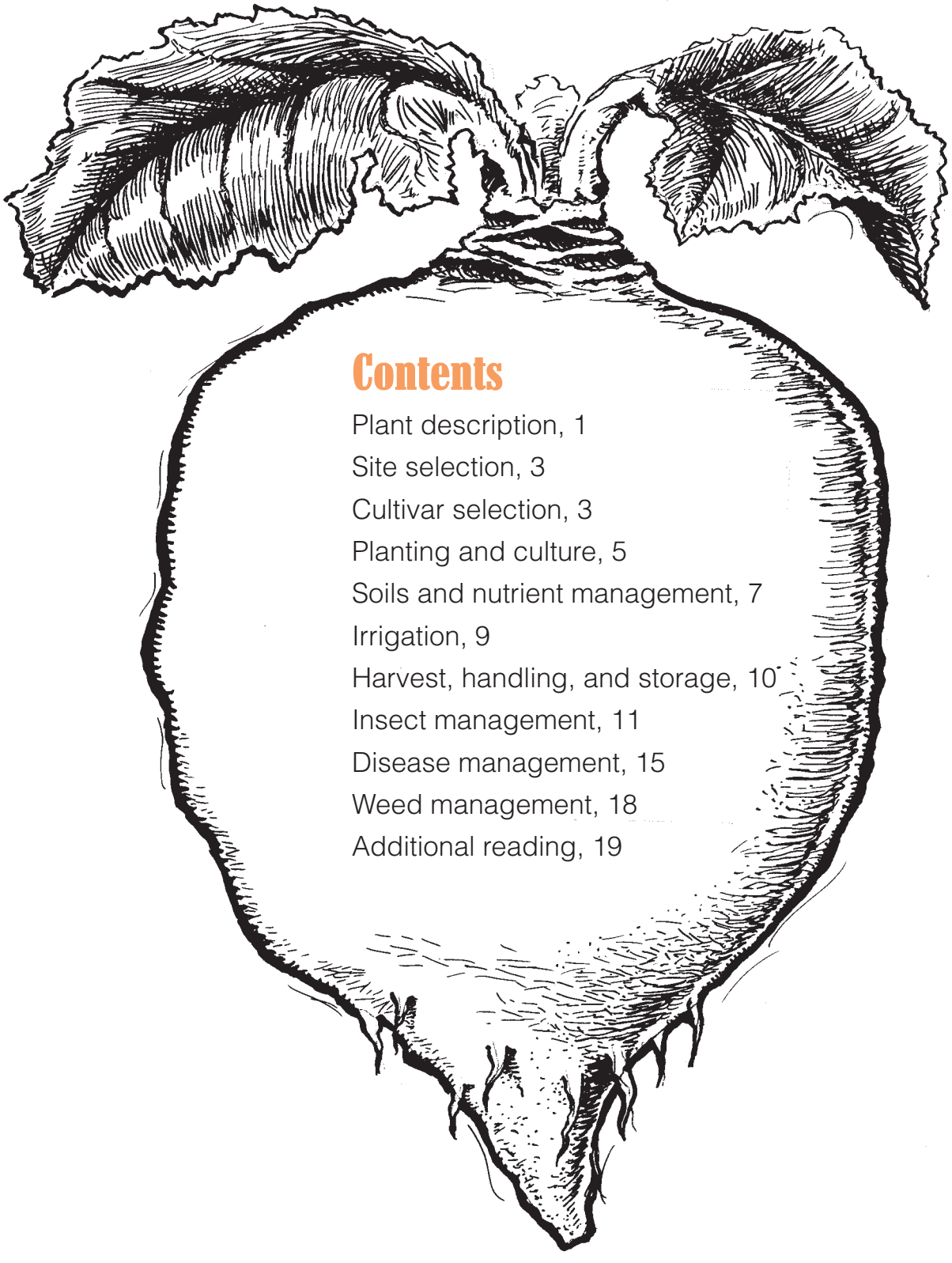
A3686



Growing carrots, beets, radishes, and other root crops in Wisconsin

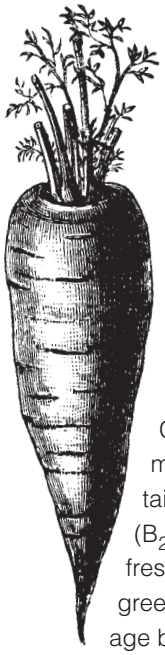
A guide for fresh-market growers

K.A. Delahaut
A.C. Newenhouse



Contents

Successful fresh-market gardening involves more than just a talent for growing high-quality vegetables. You also need to find a market for them. Before you start, visit other growers, develop a marketing plan, and evaluate the feasibility of your proposed business. Think about what is unique about your product. Are you promoting the product for taste, freshness, health benefits, value-added, or time of availability? For assistance determining your market, consult with your county Extension agent or refer to Extension publication *Direct Marketing of Farm Produce and Home Goods* (A3602).



Market gardeners typically grow several root crops in Wisconsin. The flavor of fresh, locally grown carrots far surpasses supermarket carrots. Carrots are becoming more popular as the role of beta carotene in human health is understood. Carrots contain a high amount of beta carotene, a precursor to vitamin A. Vitamin A helps prevent infection, may prevent some forms of cancer, and improves vision. Carrots are the main dietary source of vitamin A in the United States. They also contain vitamin C, thiamine (B_1), and riboflavin (B_2). Beets provide a multiseason crop for fresh market beginning with early salad greens, followed by early beets, and later storage beets. Radishes are popular in salads and provide market gardeners with an early season crop. Other root crops such as parsnips, turnips, and rutabagas may be profitable in niche markets. Properly stored root crops can extend the fresh-market vegetable season into late fall in Wisconsin.

Although carrots, beets, radishes, parsnips, turnips, and rutabagas are very different botanically, they share similar growth requirements such as soil type and cultural practices.

Plant description

Botanically, the part of the plant that we eat in all of the crops discussed in this publication is the enlarged stem below the seed leaves (the hypocotyl). There are feeder roots along this structure and a taproot below. In this publication the term "root" for root crops will refer to the edible hypocotyl portion. The vegetables fall into three plant families: Umbelliferae, Chenopodiaceae, and Cruciferae.

Carrots

Carrots, *Daucus carota* var. *sativus*, belong to the Umbelliferae family. Red carrots were originally cultivated over 2000 years ago as medicinal plants in middle Asia. Red carrots remained the standard until the 17th century when white, purple, yellow, and orange varieties were selected. These colors are still found in carrots grown in some areas of Europe and Asia, although orange has become the standard in the United States.

Carrots are biennials. They form a rosette of herbaceous leaves and the edible root the first year. If left in the ground the second year, carrots produce a short branched seed stalk which bears an umbel type of flower cluster. Queen Anne's lace is a wild form of carrot and produces the typical carrot flower. Carrot flowers are white and contain both male and female parts. Honey bees are the main pollinator. Flowers are produced after the plant has been exposed to temperatures below 50°F for 6–8 weeks. Long day conditions can accelerate flowering. Under heat or moisture stress a flower stalk may develop during the first year. Stored sugars then break down and move from the carrot root to the flower which causes carrots to become woody and inedible.

Carrot seed leaves (cotyledons) are strap-like. True leaves are fern-like and doubly compound. Carrot roots are composed of four distinct sections: peel or periderm, cortex (comprised of the phloem, or food-conducting tissue), cambium, and the central core (comprised of xylem, or water-conducting tissue). Sugar and carotene are concentrated in the cortex.

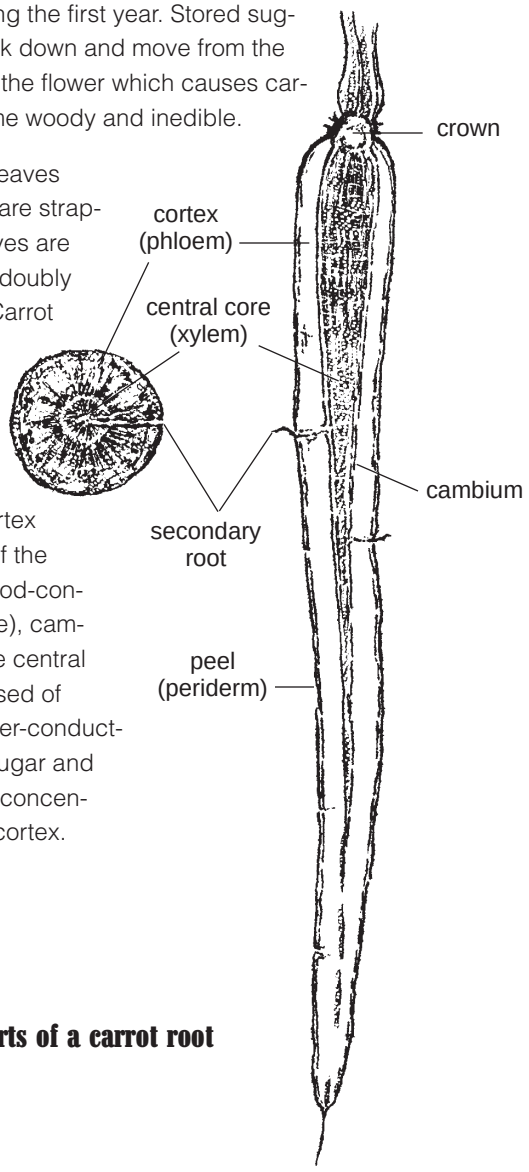


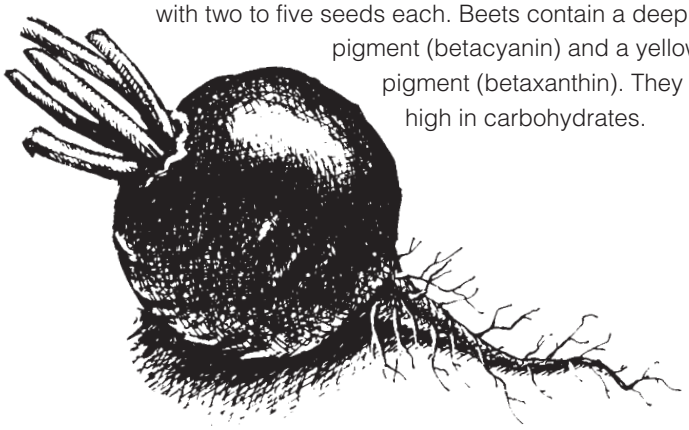
Figure 1. Parts of a carrot root

Parsnips

Parsnip, *Pastinaca sativa,* is also a member of the Umbelliferae family. Parsnips are native to the Mediterranean. Parsnips resemble long, white, tapered carrots, and have high niacin levels similar to carrots. Like carrots, parsnips are hardy biennials although they are treated like slow-growing, cool-season annuals. After planting in spring, they are harvested in late fall of the first year or early spring of the second year, before the plant begins to flower. Parsnip leaves are pinnately compound with smaller upper leaves attached directly to the stalk. Flowers are umbels with both male and female parts. They are pollinated by bees and blow flies.

Beets

Beets, *Beta vulgaris*, are grown for both their edible roots and greens. This publication will discuss beet root production. Beets belong to the Chenopodiaceae or goosefoot family, along with Swiss chard, spinach, celery, and parsley. Beets originated in western Europe and north Africa where they were grown to feed both humans and livestock. Beets contain alternating light and dark bands or zones of phloem and secondary xylem. This crop is a biennial grown as a cool-season annual. During the first year, they produce a basal rosette of fleshy triangular leaves with long petioles, and the edible beet root. If plants are left in the ground the second year, a flower stalk is produced. If beets are exposed to temperatures below 50°F for 2–3 weeks their first year they will bolt and produce flowers. Flowers contain both male and female parts and are borne in a panicle. Thrips pollinate beet flowers. After pollination, a corky seed ball develops which contains one or more fruit with two to five seeds each. Beets contain a deep red pigment (betacyanin) and a yellow pigment (betaxanthin). They are high in carbohydrates.



Radishes

Radishes, *Raphanus sativus*, belong to the Brassicaceae family (cole crop family). Like other brassicas, radishes contain mustard oils, which give them pungency. Radishes were originally cultivated in China. There are quick-growing spring type radishes and slow-growing summer and winter radishes. Daikons are a long white Asian type of winter radish. Radishes may be grown as a cool-season annual sown in the spring and early summer, or as a biennial if sown in fall. Radish leaves are deeply pinnate and form a basal rosette. Most radishes produce a flower stalk the second year, after cool temperatures followed by long days initiate bolting. Flowering or bolting in annual radishes can occur after roots reach edible size and the plant is exposed to warm temperatures. Once the plant produces a flower stalk, radish flavor and quality deteriorate. Rose or white flowers are borne in an elongated raceme and have the characteristic cross shape of brassicas. Radish flowers are insect pollinated.

Rutabagas and turnips

Rutabagas, *Brassica napus* var. *napobrassica*, and turnips, *Brassica rapa*, also belong to the Brassicaceae family. Rutabagas and turnips are cool-season biennials native to Asia and Eurasia. Rutabagas, also called Swedes, are thought to have originated from a cross between turnips and cabbage. Rutabagas are large, round, and have solid yellow flesh. Their leaves are smooth, fleshy and large, and grow from a short stem, unlike turnip. Rutabagas contain carotenes which are a precursor to vitamin A, although carotene levels are low compared to carrot.

Turnips are smaller than rutabagas and can be round, flattened, or elongated. The flesh is white. Turnip leaves are hairy, thin, smaller than rutabaga leaves, and are used as greens. This crop requires a shorter growing season than rutabagas. Rutabagas and turnips form yellow flowers in a raceme the second year. Both flowers readily cross pollinate, but turnips require cross pollination to produce seed whereas rutabagas are self-fertile. If rutabagas are exposed to temperatures below 50°F for 3–6 weeks flowers are induced. When flower production begins, root flavor and quality deteriorate.

Site selection

Choose a sunny site with deep, friable soil for root crops. Soils may range from organic muck soils to sandy loams. A compaction layer or shallow plow pan will hamper root growth. Root crops grow best on fluffy soils with good tilth. Root crops can tolerate a wide pH range. Carrots, parsnips, and rutabagas grow well in pH 5.5–7.0, radishes in 6.0–7.0, and beets in 6.0–7.5.

Table 1. Recommended cultivars

Carrots

Long
A Plus
Imperator
Ingot
Orlando Gold
Savory
Scarlet Nantes

Half-long
Artist
Lucky B
Nantes
Nelson
Pioneer
Red Cored Chantenay

Baby
Little Finger
Minicor

Beets
Big Red
Burpee Golden
Chioggia (striped)
Cylindra
Detroit Dark Red
Detroit Supreme
Lutz
Ruby Queen
(bunching type)

Radishes

Spring type
Cherry Belle
Early Scarlet Globe

Summer type
French Breakfast
Snow Belle (white)
White Icicle (white)
Red Meat

Winter type
April Cross
Round Black Spanish

Parsnips
Lancer
Harris Model
Andover
All America

Rutabagas
American Purple Top
Laurentian
York
Fortune

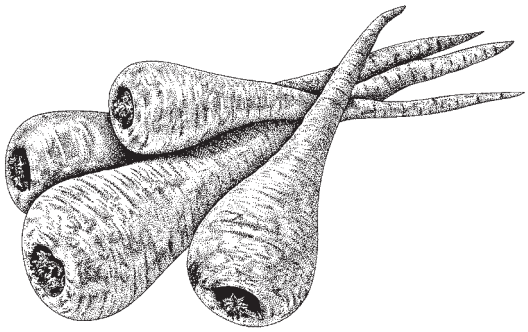
Turnips
Purple Top White Globe
Golden Ball
Just Right

Cultivar selection

Refer to table 1 for a list of some suggested root crop cultivars for Wisconsin.

Carrots

Carrots are grouped according to shape and market use into four classes: Imperator, Nantes, Chantenay, and Danvers. Imperator carrots are grown for fresh market sale and sold either in bunches with their tops or in bulk without. Imperator carrots are long and tapered and have a deep orange cortex with a lighter orange core. Harvest Imperator carrots before they mature and become woody. Nantes carrots are also grown for fresh market sale. They are bright orange, short, and cylindrical with a blunt, rounded base. Baby Nantes cultivars are only ½–¾ inch in diameter and 2½–3 inches long. They typically have a small core, sweet flavor, crisp texture, and high quality. Carrots of several cultivars can be harvested as baby carrots when immature. Chantenay carrots are short, tapered and are primarily for storage or processing. Chantenays are tender and crisp, and vary from medium to light orange. Danvers carrots are longer than Chantenay but are also short and tapered. Their deep orange flesh is often tinged with green. Most Danvers varieties are processed into baby food.



Note: Choose cultivars according to your own situation and needs. Consider what your market demands, the length of your growing season, your soil, pests, diseases, irrigation, cultivars other growers like, and cultivars you personally like. When trying a new cultivar, do not use it exclusively. Grow new trials next to old standbys so you may compare the characteristics objectively.

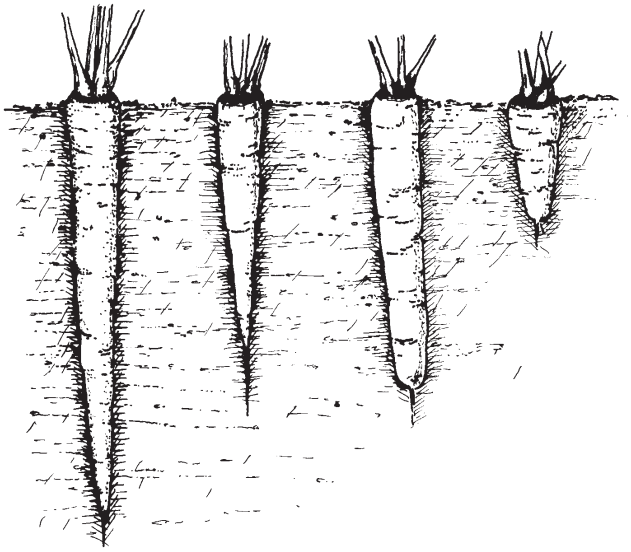


Figure 2. Carrot types, from left: Imperator, Danvers, Nantes, and Chantenay

Carrot breeders have focused on producing sweet carrots with high vitamin A content, deep orange-red color, and uniform size and shape. Disease resistance has also been a main focus of carrot breeding programs. Cross breeding is necessary in carrots to maintain plant vigor.

Parsnips

Parsnips are bred for flavor, smooth long roots and canker resistance. Lancer, Harris Model, Andover, and All America are recommended parsnip cultivars.

Beets

Beet cultivars are described by their color and shape. They may be red, yellow, purple, white or striped, top-shaped, globe-shaped, flattened or elongated. Beets are also further classified by their intended use, such as storage, slicing or bunching. Plant breeders select beets for taste, uniform color between the xylem and phloem rings, and the production of one seed per fruit for more reliable seed spacing.

Radishes

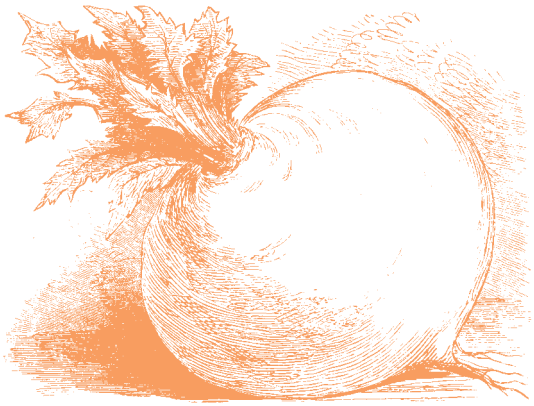
Radish cultivars are grouped according to the season in which they will be grown. Cultivars may be classified as spring, summer, or winter radishes. Spring radishes are globe-shaped and bright red, white, pink, or purple. They mature in only 25–30 days. Summer radishes are similar to spring radishes but are larger and slower to mature. Summer and winter radishes require approximately 50–60 days to mature. Winter radishes favor cool temperatures and short days and are grown as a fall crop in Wisconsin. Radish breeders select for taste, bolt resistance, disease resistance, and appearance.

Rutabagas

Recommended rutabaga cultivars for Wisconsin are American Purple Top, Laurentian, York, and Fortune. Breeders look for rutabagas resistant to clubroot disease to which all brassicas are susceptible.

Turnips

Purple Top White Globe is a standard American turnip cultivar. Golden Ball is a yellow-fleshed, summer cultivar. Just Right is an F_1 hybrid with a large, smooth, white root. Plant breeders select for taste, production of hybrid vigor and uniform growth in turnips.



Planting and culture

Refer to table 2 for the estimated amount of seed required, seed planting depth, yield, planting date, spacing, and days to first harvest.

In general, carrots, beets, turnips, and parsnips may be planted around April 15 in southern Wisconsin. Growers in the northern part of the state should wait until late April before seeding these crops. Seeds are often treated with a fungicide to reduce the incidence of seed-borne or soil-borne pathogens which cause seedling diseases.

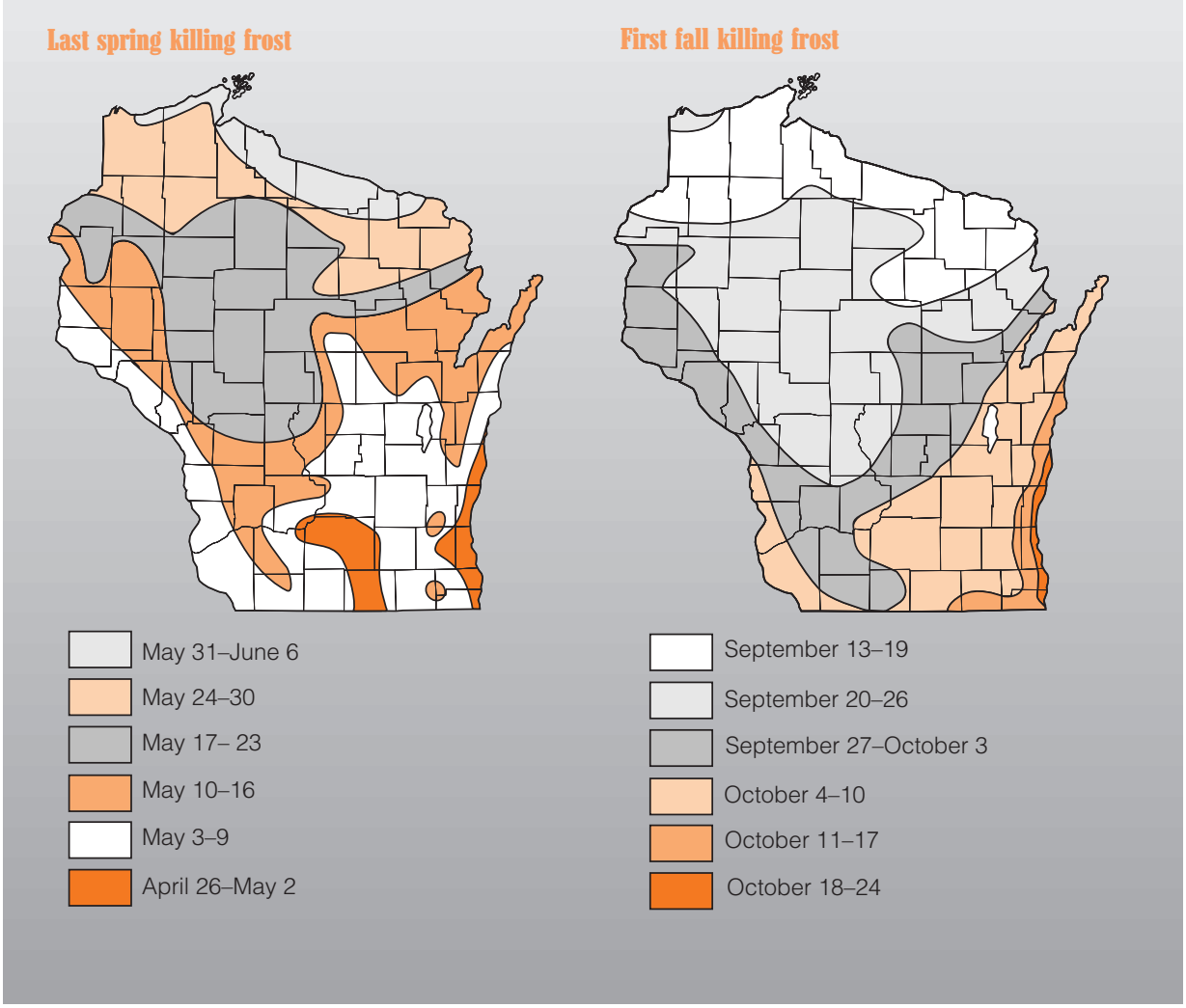
Most root crops grow during spring or fall, when cooler night temperatures slow respiration and carbohydrates are stored in the roots. Long-season crops such as parsnips, turnips, and rutabagas are sown in the spring and harvested in late fall or winter.

Soil preparation

Seedbed preparation is the most important step in growing root crops. Soils must be rich, deep, and friable. Well-drained soils are essential to prevent soil-borne pathogens from infecting the plants. Use deep tillage to remove any plowpan compaction at a depth of 6–8 inches. Before planting, remove clods, rocks, and plant debris to prevent irregular growth or stunting.

Raised beds. Raised beds are an alternative to the conventional field planting method, and are often used to improve carrot growth and shape. This planting system improves soil drainage and allows access to the crop without causing soil compaction. Raised beds are typically 4–5 feet wide and 100 feet long. The width is determined by the type of equipment used and by the crop. Leave a 1-foot aisle on either side of each bed to accommodate foot traffic.

Figure 3. Approximate dates for first and last killing frosts



Seeding

Root crops are often precision seeded with mechanical seeders that prevent the need for subsequent thinning. Precision seeding requires specialized planters and uniformly sized seeds. Specialized planters are available such as the gravity-feed cone seeder, belt-driven seeder, and vacuum seeder. Walk-behind plate-type seeders are also used. Pelleted or coated seed is uniformly sized; it is available for some root crops. Plantings are often irrigated until germination to prevent the soil from crusting and causing uneven stands.

Carrot culture

Carrots grow best at 59°–65°F, where rapid growth promotes good flavor. In warmer temperatures, coarse roots with poor flavor develop, and roots are short and more blunt. Misshapen carrots form in soil with stones or clods, and forked roots tend to form in heavy soils. On sandy soils or muck soils where blowing particles can shear tender germinating carrot seedlings, you can interplant strips of annual small grain crops such as oats to form a windbreak. Some growers will allow nearby grassy weeds to remain and act as a windbreak instead of planting a small grain. Windbreak effects typically extend to 2½ times the height of the windbreak. For example, a 2-foot-tall windbreak will reduce air flow up to 5 feet away on the lee side. After the carrots have become established, mow the grain seedheads or kill it with an herbicide to prevent volunteer grain weeds. If you choose herbicide applications, apply the first one before carrot emergence. This application won't kill the grain crop but will reduce its vigor. Make a second herbicide application once the second set of true leaves emerges from the carrot seedlings. When the third true carrot leaf emerges, use a knockdown herbicide to kill the small-grain nurse crop or the weedy windbreak.

Hoe or cultivate soil around the top part of carrot roots to prevent them from turning green in sunlight. Carrots are typically seeded in three rows per bed with the seeds equidistant to each other. They can also be planted ¾–1 inch apart in 2-inch wide rows 16–24 inches apart, or in single rows 15–30 inches apart. Sow carrots 3 weeks apart to extend your harvest season in spring and fall. Carrots can withstand mild frost and light freezes.

Parsnip culture

Grow parsnips under the same conditions as carrots but space them slightly farther apart since they grow slightly larger than carrots (table 2). Parsnips grow best at 60°–65°F and cannot tolerate heat as well as carrots can. Parsnips become sweeter after a late fall frost.

Table 2. Planting guide

Vegetable	Planting time in southern WI[a] outdoors	Seeds needed for 100 ft row	Seed depth (inches)	Spacing (inches)		Days to first harvest[b]	Estimated yield (lb/ft of row)[c]
				between rows	between plants		
Carrot	April 15	¼ oz	¼	15–30	1–3	60–70	1–1½
Beet	April 15	1–1¼ oz	½	15–30	2–4	50–60	½–1½
Radish	April 15	1 oz	½–¾	8–18	1–2	25–30	½
Parsnip	April 15	½ oz	½–¾	18–36	2–4	100–120	1½
Rutabaga	June 15	⅛ oz	¾	18–36	6–8	100–110	3
Turnip	April 15	¼ oz	½–¾	12–36	2–6	40–70	2

[a] Plant about 1 week later along the lower lake shore and in the central part of state and about 2 weeks later in northern counties.

[b] Cultivars vary greatly in time needed to reach harvest stage; extend the harvest season by planting cultivars of different maturity dates or by making successive plantings of the same cultivar.

[c] Estimated yields under less than ideal growing conditions; actual yields will vary widely with weather, soil fertility and cultural practices.

Beet culture

Beets produce their best flavor with rapid growth at 55°–70°F. "Zoning," or alternating dark- and light-colored rings, become visible in roots after severe temperature fluctuations. Plant seeds 2–4 inches apart in double rows or in 2- to 4-inch bands. Space rows or bands 15–30 inches apart. Sow beets 2–3 weeks apart to extend your harvest season in spring and fall. Beets can tolerate mild frost and light freezes.

Radish culture

Spring radishes develop their best flavor if rapid growth with plenty of moisture occurs at 60°–65°F. Radish quality and flavor decline in warmer weather. Plant spring radish seeds 1 inch apart in rows 1 foot apart. Plant winter radishes 2 inches apart in rows 18 inches apart. Spring radishes can be planted in raised beds to encourage a rapid, complete plant canopy that prevents weed growth. Since spring radishes produce a crop so quickly, they can be interplanted with slower growing crops such as late cabbage, peppers, or tomatoes.

Radishes can be planted before the last frost in spring. Sow radishes every 10–14 days in spring to extend your harvest, and repeat for a fall crop.

Rutabaga and turnip culture

Plant rutabagas and turnips as late as possible to mature before a hard freeze, since both grow best in cool temperatures. Both rutabagas and turnips can tolerate frost and light freezes. Plant rutabaga seeds 6–8 inches apart in rows 18–36 inches apart. Plant turnips 2–6 inches apart in rows 12–36 inches apart.

Soils and nutrient management

Obtain a soil test to determine the level of available nutrients before planting a field for the first time and routinely thereafter at least once every 3 years. After 3 years, soil conditions can change enough to make your current fertility management program obsolete. For information on how to collect good samples and where to send them for analysis, see Extension publication *Sampling Soils for Testing* (A2100).

Routine soil tests include pH, organic matter content, phosphorus, and potassium. Special tests are available on request for nitrate-nitrogen, calcium, magnesium, sulfur, boron, manganese, and zinc. You will receive the results of your soil test along with fertilizer recommendations based on your cropping history and planned use of the field.

Root crops can be grown on a wide variety of soil types, but soil tilth characteristics are critical. Refer to the site selection section on page 3 for a discussion of soils for root crops.

Fertilizer needs

Plants take up nitrogen as nitrate (NO_3^-) or ammonium (NH_4^+), phosphorus as phosphate (P_2O_5), and potassium as potash (K_2O). These chemicals, as fertilizers, can come from organic or inorganic sources. With adequate environmental conditions, soil microbes break down organic matter and supply the chemicals that plants need to their roots. Organic fertilizers can also improve soil tilth and health. Inorganic fertilizers can be used to supply a more readily available form of primary nutrients to plants.

Organic fertilizers can come from a variety of sources such as manures, compost, fish meal, and bone meal. Each material contains varying amounts of specific nutrients. Table 3 lists organic fertilizers and the amounts of nutrients in each. For more information on this subject, refer to Extension publication *Organic Soil Conditioners* (A2305). Table 4 lists guidelines for nutrient management to compare with your soil test results.

Fertilizer should be broadcast or applied in a band 2 inches to the side of the row and 2 inches below the seed depth. On sandy soils, split nitrogen into two to three applications over the course of the growing season. Too much nitrogen on carrots, radishes, or parsnips will cause excessive top growth.

Carrots also need moderate amounts of manganese, boron, and copper. Carrots grown in copper-deficient muck soils have poor color.

Test your soil for boron before growing beets. Beets grown in soils deficient in boron will develop black spots in the phloem tissue and dry rot on the root surface. Boron deficiency is most common on calcareous soils and under drought conditions. Some plants such as muskmelon and sweet clover accumulate boron, and their composted leaves may be added to soil to raise soil boron levels. Excessive boron in soils may cause poor beet seed germination. Rutabagas are also susceptible to boron deficiencies and develop brown, water-soaked spots in the core of the root.

Radishes need moderate amounts of boron, copper, manganese, molybdenum, and zinc. Soil test results will show recommendations to add zinc or to alter soil pH to make more molybdenum available.

Table 3. Nutrient composition of various organic fertilizers

Material	N	P_2O_5	K_2O
Alfalfa hay	2.0–3.0	0.2–0.6	2.0–3.2
Bone meal	0.2–1.0	12.0–14.0	—
Compost[a]	0.5–3.5	0.5–1.0	1.0–2.0
Fish meal	9.0–11.0	5.0–8.0	0.0–3.0
Greensand	—	—	7.0
Manure, cow	0.5–0.7	0.2–0.4	0.5–0.8
Manure, sheep	1.0–2.0	0.7–1.0	0.5–2.0
Manure, poultry	1.1–1.7	1.0–1.3	0.5–1.0
Rock phosphate	—	20.0–30.0	—
Soybean meal	7.0	0.5	2.3

[a]Nutrient analysis of compost will vary based on the source.

Irrigation

Moisture stress can reduce crop yield. If leaves begin to wilt midday, plants are moisture stressed. Plants that wilt intermittently may produce smaller yields, while plants that wilt frequently or that wilt too long often die due to irreversible cell damage.

Most root crops require irrigation prior to germination to prevent a crust from forming on the soil which impedes germination. After germination, irrigation is only necessary during drought or on typically dry soils such as sand. Both drip and overhead sprinkler irrigation systems are effective, such as trickle tape, solid set, and traveler hose wheel. Radishes require adequate soil moisture to prevent them from developing an overly pungent taste. Carrot yield is higher with an even water supply, which can prevent cracking caused by wet weather immediately following dry weather. If you irrigate your soil, be sure to closely monitor micronutrient levels to prevent deficiencies.

Table 4. Annual nitrogen, phosphate, and potash recommendations for root crops

	Nitrogen				Phosphate and potash			
	Organic matter	Amount to apply		Yield goal	Amount to apply[a]			
					P_2O_5		K_2O	
Vegetable	%	lb/a	oz/100 sq ft	tons/a	lb/a	oz/100 sq ft	lb/a	oz/100 sq ft
Carrot	<2	120	4.5	20–30	45	1.7	240	9.0
	2.0–4.9	100	3.75					
	5–10	80	3.0					
	>10	60	2.2					
Beet	<2	120	4.5	15–20	20	0.75	120	4.5
	2.0–4.9	100	3.75					
	5–10	80	3.0					
	>10	60	2.2					
Radish	<2	60	2.2	1.5–2.5	10	0.4	20	0.75
	2.0–4.9	40	1.5					
	5.0–10	20	0.75					
	>10	10	0.4					
Parsnip	*	86	3.2	10	31	1.2	48	1.8
Turnip, rutabaga	<2	120	4.5	15–20	20	0.75	120	4.5
	2.0–4.9	100	3.75					
	5.0–10	80	3.0					
	>10	60	2.2					

[a]Amounts are for optimum soil test levels. Apply 50% of the given rate if the soil test is high and omit if the soil test is excessively high. If soil test is low or very low, increase rates according to the soil test recommendations.

*Nitrogen recommendation for parsnips is based on average soil organic matter.

Harvest, handling, and storage

Harvest root crops when they are sweet and sizeable but not too large or fully mature. Harvest root crops all at once with a tractor-pulled digger-lifter or by hand after loosening the soil with a fork. Crops sold without their tops are usually topped by machine during harvest, while bunched crops are pulled by hand after they are dug by machine. Make bunches of radishes, beets, or turnips in the field by wearing a supply of rubber bands on one wrist and forming the bunch with the other hand as you go.

Harvesting & packing tips

When you harvest root crops, change your position often to minimize stress and fatigue to your body. Use garden carts and wagons as much as possible to minimize lifting and hand carrying heavy produce. Standardized vented plastic containers that stack are easy to load and unload, and clean.

With a smooth level floor in the packing area, a palletized packing and storage system can be designed to fit small-scale operations (small pallets moved with a hand-pulled pallet-jack) or large operations (pallets moved by forklift). Heavy boxes of produce can be moved from one area to another on roller tables.

Layout your washing and packing area to minimize stooping, lifting, and carrying. Set up barrel washers, screen tables or water baths at table height. Ideally, tables could be adjusted to match each worker, so that work is performed at a height between wrist and elbow.

Root crops can be washed clean in a rotating barrel type of washer, or with a strong spray of water directed at produce placed on screen tables, or soaked in a water bath. After washing, allow root crops to dry on screen tables and pack them into waxed cardboard boxes. It is very important to maintain high humidity to prevent shriveling. Line boxes with a damp cloth, or pack produce in perforated plastic bags. Store root crops in a cooler at 32°F and 95% relative humidity.

Carrots

Fresh market carrots are often sold as bunch carrots with their tops, and are harvested by undercutting the roots and then pulling and bunching them by hand. Carrots are usually ready to harvest 60–70 days after planting. Immature, bunched carrots will keep for 2 weeks in a cooler. Carrots planted for storage are ready approximately 100 days after planting, just before the ground freezes. Remove their tops. In a cooler at high relative humidity, storage carrots will keep 7 months.

Parsnips

Harvest parsnips after a light frost. Low temperatures (32°F) make parsnips sweeter by causing root starches to convert to sugars. The longer parsnips are stored, the more starch in the root is converted to sugar and the sweeter they taste. Parsnips can be stored in a cooler or in the field over winter if a thick mulch is used to prevent the ground from freezing.

Beets

Harvest beets when roots are still round and tender, usually 50–60 days after planting. Beets are typically sold in bunches and will keep in top quality in a cooler for 10–14 days. Mature, topped beets for storage will keep 6 months in a cooler.

Radishes

Harvest spring radishes 20–25 days after seeding as soon as they reach marketable size. Radishes quickly turn pithy if left too long in the field. Hydrocool radishes by submerging them in cool water for a few minutes to remove field heat. Bunched radishes keep 1–2 weeks in a cooler and topped radishes keep 3–4 weeks. Winter radishes are ready 50–60 days after planting. Daikons are brittle and easily break during harvest. They are usually sold with 2 inches of leaves left on, and will keep in a cooler for 6–10 weeks.

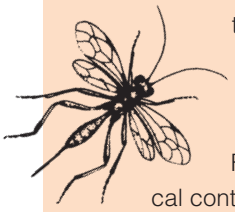
Rutabagas

Rutabagas are ready to harvest 100–110 days after planting, and they become sweeter after frost. They should be 3–5 inches in diameter and trimmed of all but 1–2 inches of leaves. Rutabagas keep in a cooler for 6 months.

Turnips

Turnips are ready either when young, small, and smooth at 30 days after planting, or full size at 40–50 days, although they're sweeter 60–70 days after planting. They can be 1½–3 inches in diameter. They are sold either with or without greens. With greens, turnips keep in a cooler for 10–14 days. Mature, topped turnips keep up to 6 months.

Conservation of natural enemies



Not all insects are pests. Beneficial insects prey on other insects, helping to keep populations in check. You can take advantage of this free natural resource by minimizing the use of broad-spectrum insecticides. For more information about biological controls, see Extension publication *Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and Their Use in Pest Management* (NCR481).

Insect management

Aster leafhopper

Description: The aster leafhopper is a serious pest of carrots because it transmits the aster yellows phytoplasma (discussed in disease section). Adult aster leafhoppers are olive-green, wedge-shaped, and about ⅛ inch long. Adults have six spots on the back of the head. Nymphs are similar in shape to the adults, but are cream colored and lack fully developed wings. Adults are extremely active and jump, crawl, or fly when disturbed. Nymphs are less active but crawl rapidly.

Life cycle: The first leafhoppers that appear each season migrate from the Gulf states. Each year they they are carried in on warm, southerly winds. Large influxes may occur in June and early July as local populations develop. Adult females lay eggs in the leaves of susceptible plants. Nymphs hatch 5–7 days later and mature in 20–30 days. There are normally two to five generations per year.

Damage/Symptoms: Both nymphs and adults feed by inserting piercing-sucking mouthparts into the plant to extract sap. If a leafhopper feeds on an infected plant, it ingests the aster yellows pathogen. When the leafhopper moves to another plant to feed, it transmits the pathogen in its saliva. In carrots, disease symptoms appear about 3 weeks later. Symptoms may appear as early as 10 days after infection or as late as 40 days after infection.

Management: Aster leafhoppers may be effectively controlled by excluding them from the carrot planting with floating row covers. Row covers should be in place from the time the carrots emerge until 30 days before harvest. Drape the covers over the crop or support it using wire hoops. Hold the material in place by burying the edges or by weights such as reebar. Completely seal all four edges to the ground.

If you're not using row covers, the only effective way to prevent the spread of aster yellows disease is through insecticidal control of aster leafhoppers. To control leafhoppers, you need to know both the size of the population and the percent of the population that's infective. Place yellow sticky cards in the field

early in the spring when plants are newly sprouted. Place the cards just above the crop a few rows in from the outer field edge. Begin scouting weekly when you find leafhoppers on the cards. Use a sweep net to take 25 sweeps per site, and sample two sites per acre. Each spring, the University of Wisconsin-Extension collects samples of migrating leafhoppers and determines the percentage that are infective. For current information, contact your county Extension office. If the percent of infectivity is not known, use 2.5% for the following calculations. To decide whether treatment is necessary, multiply the number of leafhoppers per 100 sweeps by the percent infectivity of the migrant populations. Treat resistant carrot cultivars when an index of 100 is reached, intermediate carrots at an index of 75, and susceptible cultivars when the index is 50. Because it takes a month for the symptoms of aster yellows to develop, treatment may be discontinued 30 days before harvest.

Remove weeds from field edges as these may be a reservoir for the pathogen. Avoid planting susceptible crops near untreated crops or weeds that the leafhopper uses for refuge. If not using insecticides or row covers, consider planting an additional 30% to offset losses due to aster yellows.

Flea beetles

Description: Flea beetles are occasional pests of beets, radishes, and turnips in the Midwest, especially in fields that are weedy or surrounded by weeds. The larvae are delicate and threadlike with white bodies and brown head capsules. Flea beetles have characteristically large hind legs, which makes them excellent jumpers. The adults are 1/12–1/10 inch long.

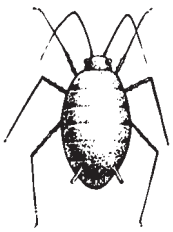
Life cycle: Flea beetles overwinter as adults in leaf litter, hedgerows, windbreaks, and wooded areas. The beetles become active when temperatures reach 50°F and emerge in late April, feeding on weeds and volunteer plants until the new crop emerges. Adults begin laying eggs in the soil at the base of host plants in May. Eggs hatch in 7–14 days and larvae feed on various plant parts until full grown. The larvae pupate in earthen cells for 11–13 days before emerging as adults. There are two generations per year in Wisconsin.

Damage/Symptoms: Adult flea beetles chew tiny circular holes or pits in the leaf tissue. On seedlings, heavy infestations may cause plant stunting or death. Large populations usually do not cause economic damage on older plants. Larvae of most species feed on roots but generally cause little damage. Larvae of the horseradish flea beetle will also mine in the stem and leaf veins. Many flea beetles are vectors of viruses and some bacteria.

Management: Early plantings may avoid high populations of flea beetles while the plants are small and vulnerable. Enclosing seed beds with floating row covers will protect plants from egg-laying adults. Removing alternate weed hosts, deep plowing of crop residue in the spring, and crop rotation will help check flea beetle populations.

Scout for adult flea beetles using a sweep net. Take 25 sweeps per site, sampling at least one site per acre. Because flea beetles can move into a field quickly, scout newly planted fields every 1–2 days. Treat with insecticides only when flea beetles are so numerous on small plants that feeding is causing stand reductions.

Aphids



Description: Numerous species of aphids feed on vegetables. The cabbage aphid and the turnip aphid are two of the more common species found in radishes, turnips, and rutabagas. Adult aphids are pear-shaped insects about 1/10 inch long.

The common wingless form of the cabbage aphid has heavy surface wax that gives it a dull green color; the wingless form of the turnip aphid is lighter green. Winged forms of the turnip aphid are pale green with black body markings and a black head.

Life cycle: Cabbage and turnip aphids overwinter as eggs on plant debris. Each female aphid typically produces 80–100 young aphids. When food becomes scarce, winged females are produced so they can colonize other sites. Aphids breed throughout the season.

Damage/Symptoms: Feeding damage from heavy infestations causes leaves to curl or wilt. Aphids, particularly cabbage aphids, can transmit viruses during feeding.

Management: Insecticidal soaps are very effective in controlling aphids. The soap must come into contact with the aphids to provide control. A spreader-sticker is often necessary to get thorough and even coverage of the soap on the plant. Several parasitic wasps naturally control both species of aphid. *Diaeretiella rapae* is a small parasitic wasp that controls the cabbage aphid and is available commercially. Reflective mulches have been shown to repel aphids by causing confusion when the winged forms are looking for a place to land. Typically, aphids look for dark areas which are present in clean cultivated fields. By using a reflective material as a mulch between rows, the aphids become disoriented when seeking a landing site.

Cutworms

Description: Cutworms are the larvae of nocturnal grey moths. They tend to feed at or just below the ground surface at night. Cutworms are active feeders on young foliage and stems and will cut off many young seedlings in an evening. The large (1½–2 inches), fleshy larvae curl up into a tight C-shape when disturbed.

Life cycle: Few cutworms overwinter in Wisconsin. Beginning in late May, moths migrate into the state. Female moths lay hundreds of eggs either singly or in clusters. Most eggs are laid on low-growing, grassy vegetation or plant residue from the previous year's crop. Once the eggs hatch, the young larvae feed above ground on the tips of plants. Larger larvae feed at or just below the soil surface at night or on cloudy days. During the day they hide in the soil or beneath foliage. There are three to four generations per year in Wisconsin, but the first generation is the most damaging because it coincides with seedling plants.

Damage/Symptoms: One large larva may destroy several plants in one evening. The larvae often pull the stem of the severed plant into their subterranean burrows.

Management: Since female moths prefer to lay eggs in grassy areas, controlling grassy weeds lessens the possibility of problems. Avoid planting in low, wet areas or in areas where grassy plants or weeds existed the previous year. Insecticides may be used in areas where cutworms historically have been a problem. Fields should be scouted if feeding damage is observed. Shake every plant along a 5-foot length of row in two adjacent rows into the furrow and count the larvae on the soil surface. Spot treat if you find two or more larvae per foot of row.

Root maggots

Description: The cabbage maggot and seed corn maggot both pose potential problems in root crop plantings. The adults of both insects are flies, similar in appearance to the common housefly. The maggots are approximately ¼-inch long, white to cream-colored, and legless with a sharply pointed head end.

Life cycle: Root maggots pass the winter as pupae in the soil. In early to mid-May, adults emerge from the soil and lay eggs on the soil surface within 1–3 inches of the plants. As the eggs hatch, the larvae begin feeding on and in the roots. There are three to five generations per year.

Damage/Symptoms: Seed corn and cabbage maggots feeding damages the root leaving brown tunnels. It may also introduce disease organisms that may kill the plant or make it unmarketable. Maggots can be especially damaging to seedlings, injuring the growing point of the root. Affected plants are often stunted and off-color. Seed corn maggots feed on ungerminated seeds as well as roots.

Management: Rutabagas are especially susceptible to root maggot damage and require stringent maggot control in southern Wisconsin. Insecticides applied at planting time are recommended in areas that routinely suffer cabbage maggot damage.

Prevention is the best method of root maggot control. Late plantings (mid-June) are generally damaged less than early plantings. To avoid heavy infestations, do not plant root crops during peak fly emergence. You can predict peak fly emergence by monitoring degree day accumulations (for a discussion of degree days, see sidebar). Begin degree day calculations once the ground thaws.

For cabbage maggots, use 43°F as the base temperature in your calculations. Use 39°F for seed corn maggots. The first generation of adult cabbage maggots peaks at 300 DD_{43}. Seed corn maggots peak at 200 DD_{39}.

An alternative method for monitoring emergence is to place three or four yellow plastic dishpans filled with soapy water along the field edge at 100 ft intervals in early April. Check traps every 4–6 days. Remove and count any flies and add fresh soapy water. Keep records of the number of flies trapped to determine when fly numbers are building up or tapering off. Floating row covers may be used to protect susceptible root crops during flights of adult seed corn and cabbage maggots.

Calculating degree days

Temperature affects the rate of development of plants and insects. Cold weather slows development while warm weather accelerates it. For this reason it is misleading to describe development in terms of time alone. To monitor crop development and predict pest behavior, professional pest managers often use a system that takes into account the accumulation of heat with passing time. This system is based on degree days (DD).

A degree day is a unit of measure that occurs for each degree above a base temperature during a 24-hour period. The base temperature is the temperature below which there is no plant or insect development. Specific insects have specific base temperatures. Most plants use a base temperature of 50°F. Cool-season plants, which includes most root crops, grow in cooler temperatures and have a base temperature of 40°F. Begin recording degree day accumulations for Wisconsin on March 1.

To monitor plant and insect development using degree days, you will need a maximum/minimum thermometer to obtain the daily high and low temperatures. Calculate degree days using the equations below.

Example: Assume you have accumulated 200 degree days to date using a base temperature of 40°F. If yesterday's high temperature was 75°F and the low was 60°F, then the daily average temperature would be 67.5°F [(75 + 60) ÷ 2]. To calculate the degree day accumulation, subtract the daily average from the base temperature for a total of 27.5DD (67.5 – 40). Add this number to the total number of degree days to date (27.5 + 200) for a new total of 227.5.

(daily high[a] + daily low[b]) ÷ 2 = daily average temperature
daily average temperature − base temperature = degree day accumulation

[a]Use 86°F if the high temperature for the day is more than 86°F.
[b]If the daily low is less than the base temperature, use the base temperature.

Disease management

Aster yellows

Hosts and severity: Aster yellows is a potentially serious disease of carrots, parsnips, and radishes as well as many other vegetables and ornamental flowers. The disease is caused by a phytoplasma organism which is similar to a virus.

Disease cycle: The phytoplasma that causes aster yellows is transmitted by at least 17 species of leafhoppers. The pathogen overwinters in the bodies of adult leafhoppers or in perennial host plants such as weeds and ornamentals. Nymphs and adult leafhoppers acquire the pathogen through feeding on infected plants. Once inside the leafhopper, the phytoplasma mutiplies. An incubation period of at least 10 days must pass before the leafhopper can transmit the pathogen back to plants. The insect may remain infective for at least 100 days. Plants first show symptoms 10–40 days after they become infected.

Symptoms: The first symptom on carrots is yellowing and vein clearing of young leaves at the center of the crown. Next, dormant buds break and grow into chlorotic shoots. This gives the plant a short bunchy or witch's broom appearance. Old leaves become twisted and reddened or bronzed. They eventually break off, leaving a top that consists only of short adventitious shoots. These plants are difficult to harvest mechanically and bunch for market. Roots of infected plants are usually malformed and have numerous hairy secondary roots arising from them. The roots tend to be stunted, woody or tough, off-flavor, and have poor color. The crowns of diseased plants are predisposed to soft-rot bacteria in moist weather. Infected carrots grown for seed propagation often die before the seed is mature.

Management: There is no cure for aster yellows, so control is aimed at disease prevention. Control leafhoppers or exclude them from susceptible crops using floating row covers. Planting tolerant cultivars of carrots, parsnips, and radishes will reduce the loss caused by the disease in years of severe outbreaks. Also, remove weeds from field edges that may serve as a reservoir for the pathogen.

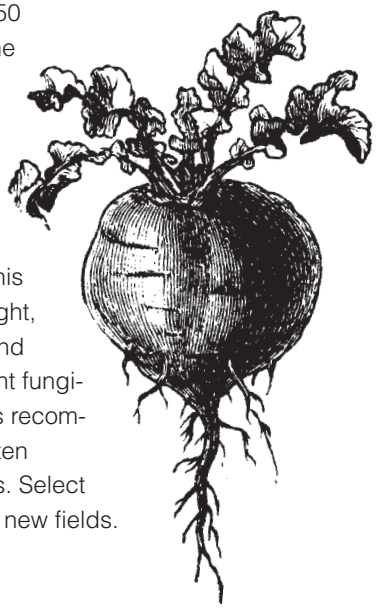
Alternaria leaf blight

Hosts and severity: Alternaria blight is a common foliage disease of carrots. In warm, moist weather, leaf spots develop so rapidly the entire field may appear to have been injured by frost or chemicals. The disease is seldom serious until plants approach maturity. Petioles of leaves weakened by Alternaria blight become brittle and often break off during harvest, resulting in unharvestable carrots.

Disease cycle: The fungus that causes Alternaria blight overwinters in diseased debris in the soil. It may also be spread on or in contaminated seed. During the growing season, spores are disseminated by wind, water, splashing rain, and field equipment. Infection takes place rather slowly unless a favorable environment is present. The fungus survives up to 2 years in the soil.

Symptoms: Initially, small, dark brown to black spots appear on leaves. The edges of leaflets turn chlorotic yellowish-green. As the irregularly shaped lesions increase in size and number, the entire leaflet shrivels and dies. The dead foliage has a burnt appearance. Large elongated lesions may form on the petiole, girdling and killing the entire leaf before any spots develop. Alternaria also causes damping off of seedlings, blights of seed stalks, and a black decay of the roots. Initially, the disease occurs irregularly, in small patches within a field. Later, Alternaria blight becomes fairly uniform throughout the field.

Management: Randomly collect 50 leaves from the field. If 25% of the leaves sampled are infected, approximately 1–2% of the crop is infected and fungicide treatment should be initiated.



Plants that exhibit nitrogen deficiency are most susceptible to this disease. To control Alternaria blight, practice a 3-year crop rotation and spray the foliage with a protectant fungicide. Fall plowing after harvest is recommended in infested fields to hasten decomposition of infected debris. Select well-drained sites when planting new fields.

Cercospora blight

Hosts and severity: Cercospora blight is another important foliage disease of carrots. It can also infect beets. Cercospora does not infect the edible carrot root. It is severe on young leaves and develops rapidly when plants are relatively young.

Disease cycle: The fungus overwinters on infected plant debris and wild hosts such as Queen Anne's lace. Spores are produced on this debris and are carried by wind or water to young carrots. The fungus enters the plant through pores in the leaf (stomata). Lesions appear after 3–5 days and new spores are produced soon thereafter.

Symptoms: The symptoms of Cercospora blight resemble those of Alternaria leaf blight but are more severe on the younger leaves and develops rapidly when plants are young. Conversely, Alternaria blight is more severe on older plants. Although lesions develop on the leaves and later cause leaf curling, Cercospora may attack any aboveground part of the plant. It does not affect the fleshy root. Leaf lesions are circular with dead centers and diffuse chlorotic borders. Lesions at the margins of leaves are somewhat elongated. The spots expand until the whole leaflet dies. During humid weather, the lower surface of the lesion turns light gray with spore masses. The fungus may also produce quantities of spores on the petiole, where tan, elliptical lesions develop. Eventually the petiole may be girdled and the leaf killed. Cercospora blight occurs in July and August.

Management: Fall plowing to hasten decomposition of infected debris coupled with a 2- to 3-year crop rotation will aid in the control of Cercospora blight. Protective fungicides are often necessary.

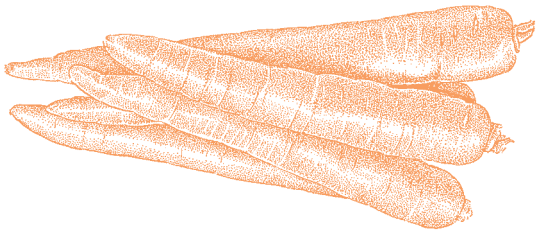
Black rot

Hosts and severity: Black rot is a bacterial disease common to plants in the cole crop family including turnips, rutabagas, and radishes. In Wisconsin, black rot is typically not serious on these crops. It is caused by the bacteria *Xanthomonas campestris* pv. *campestris*.

Disease cycle: The bacteria overwinters in diseased plant debris and in seed. Plants can be infected by the black rot bacteria at any stage of development. The bacteria survives 1–2 years on plant debris, but is often harbored in cruciferous weeds that act as a reservoir.

Symptoms: The first signs of the disease appear at the leaf tip where initial infection most often occurs. The tissue of the infected leaf turns yellow, usually in a V-shaped area with the base of the V toward the midrib. The symptomatic area soon dies and becomes tan and dry as the disease progresses. In the yellowed tissue, the veins become dark. Holding the leaf up to a bright light reveals a network of black veins. Infected roots are dark and break down internally.

Management: It is best not to save seed from turnips, radishes, or rutabagas as the disease is readily seedborne and can infect the next year's crop. To prevent problems with black rot, plant only disease-free seed. Seed grown in the western United States is recommended. Rotating fields out of crucifers for at least 3 years will reduce the likelihood of pathogen build-up in the soil. Never cultivate or move irrigation equipment while the foliage is wet as this may help spread the disease. Do not compost infected debris. To hasten decomposition, plow debris under immediately after harvest.



Clubroot

Hosts and severity: Clubroot is a serious disease of cole crops. The fungus, *Plasmodiophora brassicae,* infects the below-ground parts of radishes, turnips, and rutabagas. Although the direct effects of clubroot may not always be economically important, once the soil becomes infested, it remains so for an indefinite period, even in the absence of susceptible hosts.

Disease cycle: The organism that causes clubroot can remain in the soil for 10 years or longer. Infection occurs through root hairs and wounds. As the root enlarges and spores of the fungus are produced, soil becomes contaminated. Infested soil is disseminated by equipment, human activity, and running water.

Symptoms: The most noticeable symptom of clubroot is the abnormal enlargement of the roots. These enlargements may occur on the very small roots, secondary roots, taproot, or underground stems. The root clubs are often thickest at the center, tapering toward either end. Plants with clubbed roots are stunted and leaves may yellow or wilt. In root crops which normally have fleshy roots, infection usually only occurs on the smallest secondary roots and the edible taproots are not affected.

Management: The best method of managing clubroot is to avoid infection in the first place. Plant crucifers on well-drained soils and use clean transplants. Practice long crop rotations of at least 7 years and remember that turnips, radishes, and rutabagas are in the same plant family as cabbage, broccoli, cauliflower, and other cole crops when planning a crop rotation. Maintain a soil pH of at least 7.2. Radish cultivars such as Galahad, Red King, and Red Pak are resistant to clubroot and may be used where the disease has been a problem in the past. However, there are several strains of the fungus that causes clubroot and cultivars may be resistant to one strain but susceptible to another.

Downy mildew

Hosts and severity: Downy mildew is a cool-weather problem that affects cole crops including turnips, radishes, and rutabagas. There are several strains of the fungus, each strain causing infection only on a specific crop with no cross infection occurring.

Disease cycle: The fungus overwinters as thick-walled resting spores in diseased plant residue. In the spring, the overwintering spores germinate and infect susceptible hosts. Heavy fogs, persistent dews, and drizzling rains favor infection. Plants may be infected at any stage of development.

Symptoms: Symptoms of downy mildew first appear as small, purplish or yellow-brown spots on the leaves. Young leaves may turn yellow and drop while older leaves become tan and leathery. In severe cases, the entire leaf dies. Turnip and radish roots become discolored from the root crown downward. The flesh may be brown or black and may be discolored in a net-like pattern. In advanced stages, the skin becomes roughened by tiny cracks or the root may split open.

Management: Downy mildew can be seedborne so it is important to purchase only certified disease-free seed. Do not save seed from plants. To reduce the likelihood of infection, practice a 3-year crop rotation out of crucifers and control cruciferous weeds, particularly mustard weeds.

Black root

Hosts and severity: Black root is caused by the soilborne fungus *Aphanomyces raphani*. This disease can be economically important in radish, turnip, and rutabaga production.

Disease cycle: The fungus overwinters as thick-walled resting spores in diseased plant residue. In the spring, the overwintering spores germinate and infect susceptible hosts. The fungus enters the root where the side roots emerge from the taproot or hypocotyl. Plants may be infected anytime. The fungus survives in the soil for at least 1 year.

Symptoms: Infected areas of the root turn bluish-black and discoloration radiates inward. These areas enlarge in size until the root is girdled. Shortly after the root is girdled, the aboveground part of the plant wilts and dies.

Management: Because the fungus overwinters in the soil, crop rotations of at least 4 years out of crucifers is recommended. White varieties of radish are most susceptible and should not be planted in infested soil. The radish varieties Fancy Red II, Fuego, and Vintage are resistant to black root.

Turnip anthracnose

Hosts and severity: Turnip anthracnose may be severe on turnips, radishes, and rutabagas.

Disease cycle: The fungus overwinters on infected plant debris and weed hosts. Warm, moist conditions with temperatures of 80°–86°F favor infection.

Symptoms: The fungus primarily causes a small, dry lesion to develop on the leaves. On infected roots, small, tan or gray sunken areas develop. These lesions provide a point of entry for bacterial soft rot which can destroy the edible portion of the roots.

Management: Purchase certified disease-free seed. Prompt incorporation of diseased plant residues at the end of the season will hasten decomposition and long crop rotations of at least 4 years are recommended to reduce the amount of inoculum in the soil.

Weed management

Weed management is essential for crops to produce maximum yields. Weeds compete with crop plants for sunlight, water, nutrients, and space. Before planting, reduce perennial weed populations by smothering with a cover crop (such as buckwheat), by solarization with black plastic, by hand removal, or by using herbicide sprays. Cultivate or hoe regularly to control annual weeds.

Non-chemical weed control in root crops is often difficult because of the relatively small canopy produced by these crops as compared with bean, tomatoes, or vine crops. Repeated cultivations are often necessary to reduce weed competition in root crop plantings. Sometimes hand cultivation or hand weeding is necessary.

Chemical weed control in carrots is based on the type of soil on which the crop is grown—muck vs. mineral soil—because the species of key weeds will differ as will the selection of available herbicides.

Cultivate beets up to three times during the season. You can clip weeds which grow above the top of the beet foliage. Before planting beets you can apply a grass herbicide and incorporate it into the seedbed. After planting but before beets emerge, you can apply a broadleaf herbicide.

Additional reading

Culture

Direct Marketing of Farm Produce and Home Goods—Direct Marketing Alternatives and Strategies for Beginning and Established Producers (A3602). John Cottingham, James Hovland, et al. 1994. University of Wisconsin-Extension.

Growing For Market Newsletter. Fairplain Publications, P.O. Box 3747, Lawrence, Kansas 66046. A monthly newsletter with practical articles on all aspects of small-scale fresh market farming,

Harvesting Vegetables from the Home Garden (A2727). H.C. Harrison. 1996. University of Wisconsin-Extension.

Knotts Handbook for Vegetable Growers, Fourth Edition. Donald N. Maynard and George J. Hochmuth. 1997. Wiley.

The New Organic Grower. Second Edition. Eliot Coleman. 1995. Chelsea Green Publishing.

The New Seed Starters Handbook. Nancy Bubel. 1988. Rodale Press.

Producing Vegetable Crops. Fourth Edition. John M. Swiader, George W. Ware, and J.P. McCollum. 1992. Interstate Publishing.

Soil Test Recommendations for Field, Vegetable, and Fruit Crops (A2809). K.A. Kelling, L.G. Bundy, S.M. Combs, and J.B. Peters. 1998. University of Wisconsin-Extension.

Storing Vegetables at Home (A1135). H.C. Harrison. 1996. University of Wisconsin-Extension.

Rodale's All New Encyclopedia of Organic Gardening. Edited by Fern Marshall Bradley and Barbara W. Ellis.1992. Rodale Press.

World Vegetables: Principles, Production, and Nutritive Values. Second Edition. Vincent E. Rubatzky and Mas Yamaguchi. 1997. Chapman and Hall.

Pests

Biological Control of Insects and Mites: An introduction to Beneficial Natural Enemies and Their Use in Pest Management (NCR481). Daniel L. Mahr and Nino M. Ridgway. 1993. University of Wisconsin-Extension

Commercial Vegetable Production in Wisconsin (A3422). L.K. Binning, C.M. Boerboom, et al. Updated annually. University of Wisconsin-Extension.

Disease-Resistant Vegetables for the Home Garden (A3110). D.E. Brown-Rytlewski, M.F. Heimann, et al. Updated annually. University of Wisconsin-Extension.

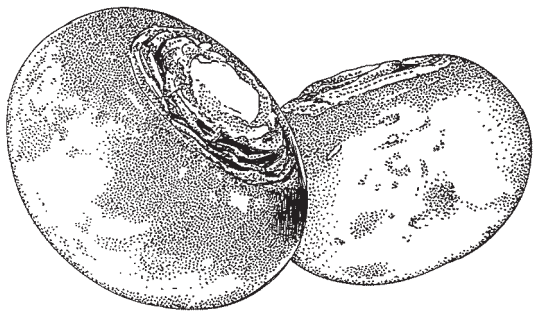
Identifying Diseases of Vegetables. A. A. MacNab, A. F. Sherf, and J.K. Springer. 1983. Pennsylvania State University College of Agriculture.

Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide. Mary Louise Flint. 1990. University of California, publication #3332.

Rodale's Color Handbook of Garden Insects. Anna Carr. 1979. Rodale Press.

Vegetable Insect Management with Emphasis on the Midwest. Rick Foster and Brian Flood, editors. 1995. Meister Publishing Company.

Weeds of the North Central States. North Central Regional Research Publication No. 281. 1981. University of Illinois at Urbana-Champaign, College of Agriculture.



Partial funding for the printing of this publication was through a grant from the Wisconsin Sustainable Agriculture Program.

Authors: K.A. Delahaut is horticulture outreach specialist for the Integrated Pest Management Program, College of Agricultural and Life Sciences, University of Wisconsin-Madison and University of Wisconsin-Extension, Cooperative Extension. A.C. Newenhouse is horticulture outreach specialist for the Wisconsin Healthy Farmers, Healthy Profits Project of the department of Biological Systems Engineering, College of Agricultural and Life Sciences, University of Wisconsin-Madison. Produced by Cooperative Extension Publishing, University of Wisconsin-Extension.

This publication is available from your Wisconsin county Extension office or from Cooperative Extension Publishing, Rm. 170, 630 W. Mifflin St., Madison, Wisconsin, 53703. Phone 608-262-3346. Please call for publication availability before publicizing.

A3686 Growing Carrots, Beets, Radishes, and Other Root Crops in Wisconsin: A Guide for Fresh-Market Growers

I-1-98-1.5M-500