

CARROTS

Bernard H. Zandstra, Department of Horticulture

Edward J. Grafius, Department of Entomology

Darryl D. Warncke, Department of Crop and Soil Sciences

Melvyn L. Lacy, Department of Botany and Plant Pathology

Production

Approximately 7,000 acres of carrots are planted in Michigan each year.

The average state yield for fresh market carrots is 8.8 tons (350 50-lb bags) of usable carrots per acre. Yields on good fields with no nematode, water, or other limiting problems may exceed 15 tons (600 50-lb bags) per acre. Minicarrots yield about 11 tons per acre. Processing carrots can yield 35 to 40 tons per acre on good fields with irrigation.

Use

Approximately 85% of Michigan carrot acreage is used to produce full size carrots for fresh market. Mini or baby carrot production for fresh pack is increasing, but is still a minor part of total production. About 15% of carrot acreage is used to produce processing carrots.

Types and Cultivars

The carrot is a biennial plant. During the season in which it is planted, the plant produces a storage root. After a period of cold temperature, the root begins to grow again and produces a seed stalk. Most carrot seed is produced in the western U.S. in areas that have relatively mild winters. Seed is planted in August and produces a small root before winter sets in. The next spring the plant resumes growth, flowers, and sets seed, which is harvested in August.

Most carrot cultivars used in Michigan are hybrids. Hybrids tend to be more uniform in quality

and maturity than open-pollinated cultivars, but the seed is much more expensive. Some growers plant open-pollinated cultivars for fall harvest because the roots do not oversize as quickly as hybrids, thus giving the farmer more latitude in scheduling harvests.

Bolting (formation of a flower stalk the year of planting seed) is a response to cold temperatures and plant size. Plants that bolt do not form a marketable root. Plants that have reached sufficient size bolt when exposed to temperatures below 50°F for an extended period of time. Although the most susceptible cultivars require less than 2 days of cold temperature to induce bolting, most cultivars used in Michigan need about 10 to 15 days.

Genetic resistance is the best protection against bolting.

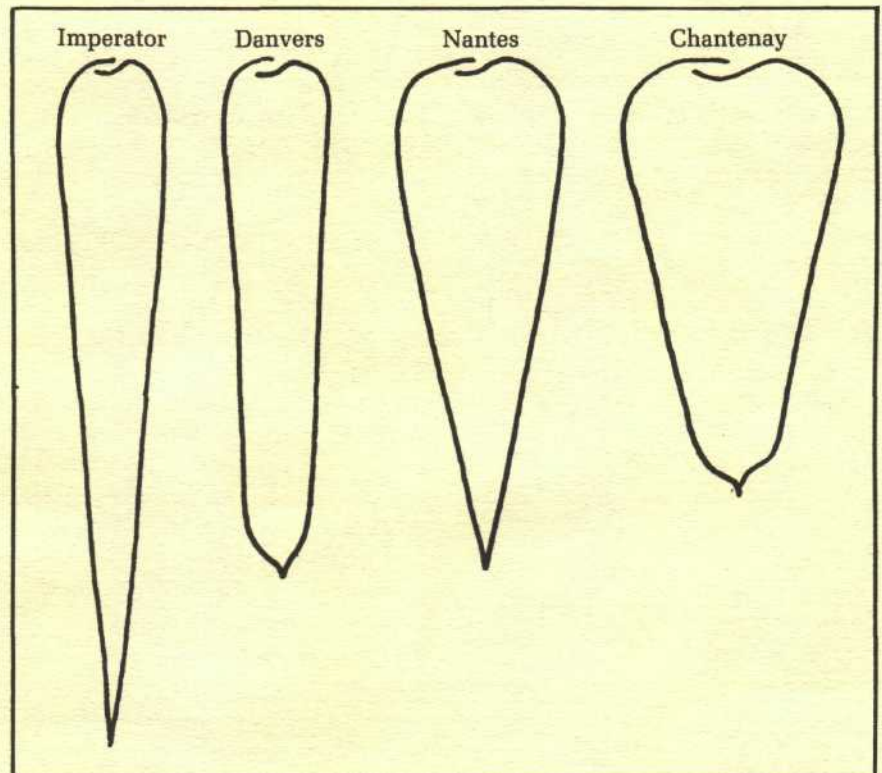
There are four main types of carrots (Figure 1):

Imperator—long, small shoulders, tapered tip; used primarily for fresh pack. Most carrots grown for fresh market in Michigan are of this type.

Nantes—medium length, uniform diameter, blunt tip; used for bunching, slicing, and mini carrots. Although not widely grown in Michigan, Nantes type carrots have a good eating quality, and are especially suited for local sales. They normally mature earlier than *Imperator* types.

Danvers—large, medium long,

Fig 1: Four main types of carrots.



processing type; used for dicing and slicing. Danvers cultivars require a long season (120 days) to develop tonnage and high sugar content. Most carrots grown for processing in Michigan are of this type.

Chantenay—large shoulders, short, usually with a large, distinctly colored core; used for dicing. These are older cultivars and usually not of the quality required by processors. They are now used primarily by home gardeners.

Qualities of Good Fresh Market Carrots

Carrot cultivars for fresh pack in plastic bags should have the following qualities:

- long (9 to 10 inches), slender, smooth, with small diameter necks (point of attachment of leaves)
- uniform deep orange or gold color (including the core)
- mild, sweet flavor
- vigorous, blight-resistant leaves
- high percentage of usable yield

Good cultivars should also be consistent producers regardless of weather and season. Unfortunately, few cultivars meet these qualifications. The following cultivars have performed better than average in Michigan trials.

Recommended Cultivars

Fresh market cellopack (*Imperator type*): Spartan Fancy 80, Spartan Delite 80, Six-Pak, Chancellor, Debut, Fanci Pak, Grenadier, Paramount, Trophy

Nantes type: Pioneer, Nantes, Scarlet Nantes

Mini carrots: Frantes, Scarlet Nantes

Processing: Spartan Bonus 80, Danvers 126

Climatic Requirements and Irrigation

Carrot is a cool season crop. Seeds germinate at soil temperatures of 40°F or higher. Roots and leaves grow best at temperatures of 60° to 70°F. Carrot seedlings grow rapidly during cool growing conditions in the spring, producing their mature-length tap roots in the first 3 weeks of growth.

Young carrot seedlings can withstand light frosts, but hard frosts heave the soil and break the tap roots, which results in stubby and forked carrots. Young seedlings are burned off easily by high temperatures that occur before the plants are 1 inch high.

Although mature carrot leaves can tolerate several nights of frosts with temperatures in the mid-20°F range, they will be killed when temperatures fall below 20°F for several hours. Because leaves are needed for harvest, recoverable yields of roots decrease as leaves are killed by frost. Healthy tops resist frost better than blighted tops.

Carrots require about 90 to 120 days to mature in Michigan, depending on cultivar and season. Harvest of early, fresh market carrots begins in late July or early August. Processing carrots are harvested in September and October. Mini carrot harvest begins in early July.

Carrots should not be exposed to water stress. When irrigating, soak the soil completely to avoid separation between sub-soil and surface moisture. A separation between moisture sources with a dry middle zone can cause differential growth and cracking. Carrots need about 10 to 14 inches of water during the growing season, depending on the soil type and water table. The water table should be maintained below 30 inches.

Weather has an adverse affect on several quality factors. Long

periods of hot, dry weather often cause a strong, unpleasant flavor. Alternating periods of slow or rapid growth caused by irregular temperatures or moisture often cause rough carrots. Saturated soil conditions after heavy rains often kill the tap roots, resulting in short, stubby carrots. Good drainage is therefore as important as a sufficient water supply for good carrot production.

Soil Requirements and Tillage

Carrots grow best on deep, loose, well-drained mineral and organic soils with good water holding capacity. Most Michigan carrots are grown on deep muck soils. Sandy and marl mucks can produce good carrots, but require more careful management. Sandy and clay soils crust easily after rains, which reduces seedling emergence and air penetration. If crusting occurs, the soil between rows should be worked with a cultivator as soon as possible.

Carrot roots are very sensitive to soil compaction. Rows next to the wheel track often have more forked and stubbed carrots than rows in the center of a bed, and usable yields are reduced. Therefore, limit movement of equipment in fields as much as possible. During the first 3 weeks of growth, stay off the field completely.

Some farmers grow carrots on raised beds. This allows the soil to drain better and warm sooner in the spring. It is of most benefit on heavy and poorly drained soils.

Fertilizer Requirements

Add lime to muck soils to maintain a soil pH of 5.5 to 5.8; maintain pH of mineral soils at 6.2 to 6.8.

It is important to maintain active foliar growth throughout the season to minimize damage from leaf blights. Hybrids are less

susceptible to cracking caused by excess fertilizer and water than open-pollinated cultivars. Therefore, it is often advantageous to increase the nitrogen fertilizer rate on hybrids if blight is a problem.

A good nutrition program maintains moderate to high nutrient levels in the soil with annual additions of fertilizer based on a soil test. Soil should be tested at least every 2 to 3 years. Soil test levels for good carrot production should be maintained at 150 lb phosphate (P_2O_5) and 350 lb potash (K_2O) per acre. Nitrogen (N) does not accumulate in soil over time, so it should be applied annually for each crop planted.

A 20-ton carrot crop removes about 100 lb N, 25 lb P_2O_5 , and 100 lb K_2O per acre. Annual supplemental nutrients can be applied in a combination of broadcast band and sidedress applications. In years between soil tests, apply about 75 lb N (up to 120 lb on sandy or marl muck), 100 lb P_2O_5 , and 200 lb K_2O per acre for carrots grown on good muck soil. For example, broadcast and plow down 300 lb 18-45-0 and 400 lb 0-0-60 per acre (54 lb N, 138 lb P_2O_5 , and 240 lb K_2O). Sidedress when carrots are 5 to 6 inches high and have 6 to 9 fern leaves with 60 lb 45-0-0 or 80 lb 34-0-0 per acre (27 lb N). Increase the sidedress N rate to 50 lb per acre on sandy and marl mucks. If heavy rains occur, apply a second sidedressing of N. On mineral soils, apply 120 lb N, 75 lb P_2O_5 , and 150 lb K_2O per acre if soil test information is not available.

Manganese (Mn) is commonly deficient in organic soils in Michigan. In carrots the deficiency appears as interveinal chlorosis (yellowing between veins of the leaves) uniformly over the whole plant. Since it is very immobile (does not move) in the soil, apply Mn in a band at planting. If all fertilizer is broadcast before planting, Mn can be foliar-applied. Apply 8 lb manganese sulfate (2 lb Mn) in

banded fertilizer at planting, or 4 lb manganese sulfate (1 lb Mn) in water as a foliar spray in mid-June to early July. Include Mn with insecticide or fungicide sprays 2 or 3 times to avoid deficiency later in the season.

Boron (B) deficiency causes necrosis (plant tissue death) in the growing tip or internal breakdown in carrot roots. To avoid this problem, apply 10 to 20 lb borax (1 to 2 lb B) per acre in the broadcast fertilizer each year. Boron deficiency occurs on both sandy and muck soils.

Copper (Cu) deficiency sometimes occurs on new muck. It results in poor orange-color development in carrot roots. If Cu levels are below 20 ppm by soil test, apply 12 lb copper sulfate or 4 lb copper oxide (3 lb Cu) per acre per year, until a total of 20 lb actual Cu has been applied. Since Cu remains available in the soil system and does not leach, additional applications should not be necessary.

Carrot Seed

To obtain a high percentage of marketable carrots at harvest, carrots must be uniformly spaced in the row. Precision seeders place seeds accurately and can be used successfully for carrots. However, because carrot seed is very small, most precision seeders can plant the seed only if it has been pelleted or coated. To obtain maximum benefit from precision seeding, almost every seed has to germinate and form a usable carrot root.

The flowering habit of carrots results in differences in size and maturity of the seed at harvest. These differences result in non-uniform germination and emergence when the seed is planted in the field. Early-emerging seedlings dominate later-emerging seedlings and out-compete them for water, nutrients, and light. Consequently, at harvest, there is wide variability in root size. In many

cases, up to 50% of the roots are undersized and cannot be packed.

Seed companies are trying to improve uniformity of germination. They harvest the seed at an optimum time when most of it is mature, grade it to remove large and small seed, leaving seed of a relatively uniform size, dry the seed, seal it in airtight containers, and keep it in refrigerated storage.

Some seed companies are developing a seed treatment service called priming to improve uniformity of germination of carrot seed. This process includes soaking the seed in an aerated salt solution, which brings it to a uniform level of pregermination. The seed is then dried to an optimum moisture level and sealed and stored like unprimed seed. Theoretically, priming improves uniformity of germination and seedling emergence, which should result in more uniformity at harvest. Results have been variable, but refinements in the technique may improve the effectiveness of the process.

Carrot seed loses viability rapidly when stored under damp and moderate to warm temperature conditions. To maintain viability, store seed in a cool, dry place in a sealed container or air-tight bag. Check seed for germination before planting.

Spacing and Planting

Chisel-plow land to a depth of 18 to 24 inches in the fall. Plow 12 inches deep and then follow with a roller to form a firm seedbed immediately before planting.

Planting of fresh market carrots begins about April 15 and continues through June 15. Schedule plantings to provide a continuous supply of carrots to the packing-shed throughout the season. Carrots planted in mid-April mature in about 110 days. Carrots planted during warmer weather mature in 80 to 100 days. Hybrid carrots

reach maturity and become oversized in about one week. Open-pollinated cultivars develop slower and thus have more flexibility for harvest. Processing carrots are planted from late April to early July. Processing cultivars mature in 110 to 130 days.

Plant carrots with a vegetable seeder (such as *Planet Jr.*) equipped with a 2- or 3-inch scatter shoe or multiple-row shoe. The row should not be more than 4 inches wide because of difficulties passing the leaves through the harvester. Plant enough seed to obtain about 24 live seeds per foot of row for fresh market carrots, 30 to 40 seeds for mini carrots, and 16 to 18 seeds for Danvers-type processing carrots.

Rows should be at least 15 to 20 inches apart. Closer spacing makes harvesting difficult and prevents air movement through the leaf canopy, which may result in increased blight infection. Plant carrot seeds 1/8- to 1/4-inch deep into moist soil. If soil is dry, irrigate the fields immediately after seeding. If irrigation is not available, plant seeds 3/8- to 1/2-inch deep. Make sure that the seed is pressed firmly into the soil to obtain good soil-seed contact.

Approximately 2 to 3 lb of carrot seed are needed per acre for fresh market cultivars, 4 to 5 lb for mini carrots, and 1 to 2 lb for processing cultivars. Always plant according to desired plant stand count, taking into consideration the germination rate and number of seeds per pound.

Rye or barley strips are often planted between every 3 to 6 rows of carrots to protect young carrots from wind damage. Remove wind-break strips when carrots are 4 to 5 inches high, either with herbicides or by tilling.

Harvest and Postharvest

Fresh market carrot harvest begins when carrots are of suitable size. In Michigan, harvest usually begins around August 1 and ex-

tends into November. Maximum marketable yield of fresh market carrots is usually obtained when 20% of the carrots in a field are jumbos (over 1 1/2 inches in diameter). Carrots are mechanically harvested by undercutting the roots and elevating them out of the soil and into the machine by grasping the leaves. Thus, it is important to maintain healthy leaves until the carrots are harvested.

Carrots are transported to the packingshed in trucks or trailers and unloaded into water to reduce root abrasion. They then pass through a rotary root washer and sizer before moving to the packing line.

The storage life of carrots is improved by hydrocooling, preferably before packing. The half-cooling time for loose carrots is 3.2 minutes. Cooling after packing is not as efficient as cooling before packing and thus takes more time. Carrots cannot be vacuum cooled efficiently.

U.S. No. 1 grade carrots are 3/4 to 1 1/2 inches in diameter and at least 5 inches long. Jumbos are at least 1 inch and no more than 2 1/2 inches in diameter. Fresh market carrots are usually packed in 1, 2, 3, or 5-lb plastic bags and then packed in 48 or 50 lb master bags. Jumbo carrots are packed in 25 or 50 lb bulk sacks.

Handle carrots as carefully as possible during and after harvest to avoid damaging the roots. Injuries reduce shelf life and increase chances of decay. Fresh market carrots are especially susceptible to injury because they are harvested before maturity (i.e., the epidermis is not fully developed) to obtain the desired market-size roots. Fresh market carrots can be stored for 4 to 6 weeks if held at 32°F and 95% to 99% relative humidity.

Harvest of processing carrots usually begins about October 1 and extends into late November. Because processing carrots are harvested when they are mature, they are less susceptible to injury

and can be stored for 4 to 5 months under proper conditions (32°F and 95% to 99% relative humidity). Remove excess soil and rotten carrots, but do not wash carrots before storing them. Do not store carrots in the same room as apples, pears, or other fruit, because these fruits give off ethylene gas, which causes a bitter flavor in carrots.

Insects

Consult Extension Bulletin E-970, *Celery and Carrot Insect Pests*, for pictures of pests and detailed life history information. See Extension Bulletin E-312, *Control of Insects, Diseases, and Nematodes on Commercial Vegetables*, for current control recommendations.

Aster leafhoppers (*Macrostelus fascifrons*) are the most important insect pests of carrots in Michigan. The leafhoppers do no direct damage to carrots, but transmit aster yellows to carrots, celery, lettuce, and weeds such as wild carrot, mare's tail (horseweed), and pineappleweed. Aster yellows is caused by a mycoplasma-like organism and can be controlled only by controlling the leafhopper and the weed hosts.

The adult aster leafhopper is light gray-green, 1/8 inch long, and is an active flier. The leafhopper overwinters in the egg stage on grasses and weeds in Michigan and may also migrate into Michigan from overwintering areas in Missouri and Arkansas. However, long distance migrants are probably rare in Michigan.

Check fields for leafhoppers at least 1 or 2 times per week and treat if numbers exceed 5 to 10 per 100 sweeps with an insect net. Weekly field scouting can save 4 to 6 sprays per season with no increase in aster yellows incidence.

The **carrot weevil** (*Listronotus oregonensis*) can be a severe pest of carrots, celery, and parsley. The

weevil overwinters as an adult. It lays eggs in the petioles and the larvae bore down into the crown and eventually into the root of the carrot. Damage is almost always restricted to the upper 1/3 (2 to 3 inches) of the carrot.

Crop rotation is an excellent control because the adults rarely fly. Fields with problem infestations can be identified at harvest and targeted for crop rotation or special scouting and insecticide treatments. See Extension Bulletin E-890, *Detection and Control of Carrot Weevil*, for pictures of adults, eggs, larvae, and damage, and details on monitoring.

Green peach aphids (*Myzus persicae*) are pests of many vegetable crops, including carrots. Damage to carrots is less serious than other crops because carrots are not subject to virus diseases and the aphids do not cause contamination problems as they do in leafy crops.

The green peach aphid adults are yellowish green and 1/16 inch long; the winged adults are black with green markings. They overwinter as eggs on peaches and other stone fruits and migrate to carrots in early summer. These aphids are all females and produce live young without mating. A single female can produce 100 to 200 young and populations build rapidly, especially during warm, dry weather.

Check fields for aphids regularly and treat, if necessary. Avoid excessive spraying because extremely high populations are often found in fields that are heavily sprayed with insecticides and fungicides. The aphids may develop resistance to insecticides and flourish where all natural enemies (insect predators, parasitoids, and fungal diseases) have been eliminated.

Wireworms are sometimes a problem in fields that recently have been planted with sod or have had grassy weed problems. Adult wireworms (click beetles) are attracted to grassy weeds for egg laying, and the larvae live in the soil for 2 years, feeding on plant

roots—including carrots.

Where wireworms are observed during tillage or where problems are suspected, treat with a soil insecticide prior to planting.

Nematodes

Northern root-knot, carrot cyst, root-lesion, and pin nematodes can be major limiting factors in Michigan carrot production. The problem is especially severe in fields where carrots are grown continuously. Infected carrot roots may be stubbed, forked, or knobby and have round galls on the secondary and tap roots. These nematodes also infect other vegetable and field crops; however, onions, corn, small grains, and sorghum appear to be less affected and should be considered as rotational crops to reduce soil infestation levels.

Historically, soil fumigation has been the most effective means of nematode control in carrot production. If nematode problems are suspected, have soil and roots tested for nematodes (see Extension Bulletin E-800, *Nematode Detection*). If plant parasitic nematodes are present in population densities above an action threshold, an appropriate nematode management procedure will be recommended.

Oxamyl (Vydate 2L and Oxamyl 10G) are registered for nematode control in carrots.

Diseases

Alternaria leaf spot (*Alternaria dauci*) and **Cercospora leaf spot** (*Cercospora carotae*) cause similar symptoms on leaves and are difficult to distinguish in the field. Spots on leaves have a dark center surrounded by a yellow margin. The leaves curl when lesions appear on the edges of leaf segments. Both of these diseases can be controlled by regular applications of

fungicides.

Bacterial blight (*Xanthomonas carotae*) symptoms are similar to those of the fungal blights: dark brown, water-soaked spots appear on leaves; as the lesions age, the centers become brittle and crack; the spots are also surrounded by a yellow margin. Bacterial blight may also cause small brown or maroon spots or water-soaked flecks on roots. Bacterial blight may be partially controlled with fixed copper compounds.

Aster yellows, caused by a mycoplasma, is spread by aster leafhoppers. It causes yellowing, twisting, and reddening of leaves. Young leaves do not develop fully and form a tight rosette. The tap root becomes woody, brittle, and bitter with excessive root hairs. The organism overwinters in perennial weeds of the *Umbelliferae* and *Compositae* families, such as wild carrot, wild lettuce, maretail, and pine-appleweed. Control these weeds in and around fields to reduce infection. Once leafhoppers appear in fields, apply insecticides on a regular schedule.

Storage rots are caused by a number of organisms. The most common is crater rot (*Rhizoctonia carotae*). To avoid storage rots, cool the carrots after harvest as quickly as possible to 32°F. Avoid mechanical damage to roots during harvest. Do not try to store carrots from poorly drained fields or fields that have suffered excess water damage during the growing season.

Weeds

Annual grasses and broadleaf weeds are the major weed pests in carrots. Most can be controlled with herbicides currently registered for use on carrots. However, a few resistant weeds are becoming serious problems. Several weeds in the *Compositae* family, including maretail (Con-

Lythrum canadensis), pineappleweed (*Matricaria matricarioides*), and groundsel (*Senecio vulgaris*) are somewhat resistant to both linuron (*Lorox*) and stoddard solvent. Dodder (*Cuscuta campestris*), a parasitic weed, is spreading in some areas.

A good weed control program includes both pre- and postemergence application of herbicides, crop rotation, and cultivation. Linuron is widely used both pre- and postemergence on muck soil. Because it can injure germinating carrots, apply linuron preemergence at no more than 1/2-lb active ingredient per acre. If dodder, chickweed, or smartweeds are major problems, include chlorpropham (*Furloë*) in the preemergence application.

Stoddard solvent, a petroleum distillate, can be sprayed postemergence over the top of carrots and kills most broadleaf and grass weeds. However, it is very expensive and can leave an oily taste in carrots if applied too close to harvest. Trifluralin (*Treflan*) is

commonly used preplant incorporated to control weeds in carrots planted on mineral soils.

Several additional herbicides are nearing registration on carrots. See Extension Bulletin E-433, *Weed Control Guide for Vegetable Crops*, for current recommendations.

Additional Information

More information on carrot production is contained in the following bulletins, available from County Cooperative Extension Service Offices or from the MSU Bulletin Office, P.O. Box 6640, East Lansing, Michigan 48823-6640. Some of these bulletins are for sale only. Consult your County Cooperative Extension Service Office for prices and availability.

E-312 *Control of Insects, Diseases, and Nematodes on Commercial Vegetables*

E-433 *Weed Control Guide for Vegetable Crops*

E-486 *Secondary and Micronutrients for Vegetables and Field Crops*

E-550 *Fertilizer Recommendations for Vegetable and Field Crops in Michigan*

E-800 *Nematode Detection*

E-890 *Detection and Control of Carrot Weevil*

E-970 *Celery and Carrot Insect Pests*

E-1720 *Diseases of Carrots*

E-1751 *Identifying Diseases of Vegetables*

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