VEGETABLE RESEARCH AND INFORMATION CENTER

Vegetable Production Series

# CARROT PRODUCTION IN CALIFORNIA

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## PRODUCTION AREAS AND SEASONS

California has four main production areas for carrots (*Daucus carota* L.): the southern San Joaquin Valley and the Cuyama Valley (Kern and Santa Barbara Counties); the southern desert (Imperial and Riverside Counties); the high desert (Los Angeles County); and the central coast (Monterey County).

Carrots are grown year-round in California. In the southern San Joaquin and Cuyama Valleys, carrots are planted from December to March for harvest from May to July and from July to September for harvest from November to February. In the southern desert they are planted from August to February for harvest from December to June. In the high desert they are planted from April to July for harvest from August to December. On the central coast they are planted from December to August for harvest from April to January.

### FRESH MARKET CARROT ACREAGE AND VALUE

| Year | Acreage | Average yield (*tons/acre*) | Gross value / acre |
|---|---|---|---|
| 1995 | 63,500 | 14.50 | $4,379 |
| 1994 | 58,300 | 16.25 | $3,741 |
| 1993 | 51,200 | 15.00 | $3,339 |

*Source: California Agricultural Statistics 1995* (Sacramento: California Department of Food and Agriculture, 1996).

### PROCESSING CARROT ACREAGE AND VALUE

| Year | Acreage | Average yield (*tons/acre*) | Gross value / acre |
|---|---|---|---|
| 1995 | 5,100 | 23.90 | $1,765 |
| 1994 | 4,100 | 30.90 | $2,350 |
| 1993 | 6,800 | 14.70 | $1,426 |

*Source: California Agricultural Statistics 1995* (Sacramento: California Department of Food and Agriculture, 1996).

## CLIMATIC REQUIREMENTS

Carrots, a cool-season crop, will tolerate warm temperatures early in the growing season. Roots attain optimal color when the air temperature is 60° to 70°F (16° to 21°C). Root color can deepen rapidly when temperatures are within this range 3 weeks before harvest but can decline at higher temperatures. This may explain why "white root" (pale color) is most often reported in late-planted crops. Above 86°F (30°C) the growth of foliage is reduced and strong flavors develop in the roots, reducing their market quality. Below 50°F (10°C) carrot roots and foliage grow slowly. Carrots may tolerate some frost.

## VARIETIES AND PLANTING TECHNIQUES

Consumer demand for uniform roots of deep orange color has led to extensive use of hybrids. Varieties include Avenger, CaroPak, Legend, Dominator, Six Pak II, Apache, Navajo, Six Pence, Cheyenne, Choctaw, Comanche, Flame, Blaze, Caro Pride, and Neptune. Long Imperator 58 is the standard open-pollinated variety. Nantes-type varieties, commonly grown in Europe and in home gardens, are not normally grown commercially in California.

Carrots are always direct seeded. Seedlings that survive transplanting develop secondary branches from the taproot ("forking") that are unacceptable to consumers. Both natural and pelleted seed are used. Carrot seed vary from 175,000 to 400,000 per pound and are sown at the rate of 1,000,000 live seed per acre. Higher densities are used for plantings for the cut-peeled market. Seed within a lot vary significantly in size, maturity, vigor, and germination time; emergence often occurs over several days. Seed are most commonly sown in 6 or 8 lines in beds 38 to 42 inches (95–105 cm) wide with 3 or 4 rows on each bed shoulder. Seed are placed in a narrow groove and are lightly covered or left uncovered until irrigation or wind moves soil over the seed.

## SOILS AND IRRIGATION

The upper 30 inches (75 cm) of soil should be uniform and free of barriers to root growth. Although carrots are often grown on sandy soils, the ideal soil is silt loam, which provides the best combination of water-holding capacity and drainage. Heavy soils can result in hairy, deformed roots. A favorable pH for carrots is between 5.5 and 7.0.

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A uniform water supply is critical for good color and root formation. If significant wet–dry cycles occur, the roots will split. Excessive watering discourages good color formation and may encourage disease. Carrots are usually irrigated by sprinklers to establish a stand and then furrow-irrigated. Solid-set sprinklers are used on fields that are not level or otherwise ill-suited for furrow irrigation. Drip irrigation has been tested with carrots, but the results have been poor. Surface drip tape interferes with harvest; buried drip tape must be deeper than 15 inches (37.5 cm) to avoid harvesting equipment, and at this depth it cannot distribute water evenly throughout the field.

## FERTILIZATION

If the field has some residual nitrogen (N) from a previous crop, no N need be applied before seedlings emerge. Carrot roots may fork if too much N is applied preplant. Sidedressing 60 to 80 lb per acre (67.2–89.6 kg/ha) of N is typical during the growing season. Nitrogen-deficient carrots often have leaves with an apparently healthy green appearance, but the height of tops throughout the field may be irregular. Phosphorous (P) is applied as 0-45-0 (treble superphosphate) at 400 to 500 lb per acre (448–560 kg/ha) before listing.

Petiole sampling is recommended for carrots. Researchers have determined the adequate nutrient concentrations that should be present in a dried sample of the most recently mature leaf. Nutrient levels above or below the following ranges can lead to unmarketable roots. The following table shows ranges of nutrients in carrot petiole samples from an adequately fertilized crop.

**Percentage of the total tissue**

| N | P | K | Ca | Mg |
|---|---|---|---|---|
| 1.8–2.5 | 0.2–0.4 | 2.0–4.0 | 2.0–3.5 | 0.2–0.5 |

**Parts per million**

| Fe | Mn | Zn | B | Cu |
|---|---|---|---|---|
| 30–60 | 30–60 | 20–60 | 20–40 | 4–10 |

## ROOT FORKING, STUBBING, AND COLOR

Damage to the growing root tip may cause the carrot root to fork or stub, rendering it unmarketable. Forking or stubbing often occurs within a few weeks after the seed germinate. Many diseases can cause forking. Poor soil structure, improper irrigation management, or hard freezes can also cause forking or stubbing. To help prevent forking and stubbing, prepare the soil well so that it has good tilth and drainage and avoid over- or underwatering young carrots.

As the carrot root matures, carotene accumulates, causing the root to change from yellow-white to yellow and then orange. Although varieties differ in their potential for orange color, soil fertility, temperature, and water content have the main effects on root color. The health of the leaves plays a minor role in root color unless the tops are severely stressed. If high soil moisture reduces the soil oxygen content to below 6 percent, "white root" may result. Maintain oxygen content at about 9.5 percent by adjusting the irrigation to alleviate this problem.

## INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) information is continually being developed for carrots. Cultural control methods such as mechanical cultivation, field sanitation, good drainage, and irrigation management are important components of IPM that help minimize chemical controls. Herbicides, insecticides, nematicides, and fungicides should always be used in compliance with label instructions. Contact the UC IPM World Wide Web site at http://www.ipm.ucdavis.edu for current pest management information (see *UC IPM Pest Management Guidelines*, DANR Communication Services Publication 3339).

**Weed management.** Many weeds, including summer and winter annuals and perennials, are pests of carrots. Nutsedges, both yellow and purple, are the worst weed pests in carrots. Postemergence herbicides control yellow nutsedge, but no herbicide is registered for purple nutsedge control in carrots. Cultivation and preplant chemical treatments offer some control of nutsedges, and fallow summer treatments can also be effective. Nutsedges do not compete with fall-planted carrots because nutsedge growth slows and eventually ceases as temperatures cool and as carrots provide more shade. Pre- or postemergence herbicides are available for for control of grass, cereal, and broadleafed weeds; chemicals applied to control nematodes may also control weeds. Consult your local pest control Farm Advisor for details.

**Insect identification and control.** Crickets, grasshoppers, pale-striped flea beetle larvae and adults, cutworms, and saltmarsh caterpillars can be serious pests of carrots by feeding on seedlings. Remove weeds in or near fields and disk in plant residue from infested fields to help keep flea beetle populations low. Saltmarsh caterpillars are a problem in carrot fields planted next to a cotton field that has been defoliated for harvest. Building trenches or other barriers at the border of the cotton field can stop the movement of these pests. Aphids and whiteflies can be serious pests of carrots at all stages of development. Besides directly feeding on carrots, they also vector several viral diseases. Chemical control is usually not required for aphids because naturally occurring predators and parasites help keep their populations below economic threshold levels. Field sanitation helps reduce the aphid population. Carrots should not be planted near cotton

or melons to reduce the movement of the cotton-melon aphid into carrot fields when these crops are harvested.

**Disease identification and management.** *Pythium ultimum*, *P. irregulare*, *Rhizoctonia solani*, and *Macrophomina* spp. can all cause forking, stubbing, and dieback. Soil fumigation can reduce the amount of dieback in a field and control several other pests as well. Powdery mildew, a fungal disease, can be a problem in high humidity and warm temperatures. Symptoms of powdery mildew are white powdery growths on the upper surface of the leaves. Seedling damping-off can be the result of *Pythium* spp., *R. solani*, and other soilborne fungal pathogens. Seed treatments and soil fumigation to control nematodes and/or weeds can reduce damping-off pathogens.

Cavity spot can be a severe disease of carrots that can cause the loss of the entire crop. Small, brown, water-soaked lesions develop on the root surface and may enlarge and open into a dry sunken lesion as the carrot matures. This disease is caused by the soilborne pathogen *Pythium violae*. Cavity spot generally increases in fields with a previous history of carrot plantings. Alfalfa is also a host for *P. violae*, and carrots that follow alfalfa may show symptoms. Fungicide applied preplant and in 2 to 3 postplant applications reduces cavity spot.

Root rots of carrots can be caused by several plant pathogens. Cottony soft rot (*Sclerotinia sclerotiorum*), a problem in cool, moist conditions, is a cottony white mass of fungal growth around the base of the carrot. Large black sclerotia can be found in the fungal mass and on the carrot itself. It can be reduced by deep plowing before planting and by chemical treatments. Southern blight (*Sclerotium rolfsii*) favors warm temperatures. It produces a low-lying dense mat of brown fungal growth on the soil surrounding the carrot, with brown sclerotia located throughout the fungal mat. It can be reduced by deep plowing before planting and rotating to nonhost crops such as small grains or corn. Bacterial soft rot (*Erwinia carotovora*) can be recognized as a soft rot not associated with any fungal growth and accompanied by a foul odor. It occurs in waterlogged soils during warm temperatures. Preparing the soil to eliminate low spots, increasing drainage, and avoiding overwatering are control measures for all the soft rots.

Leaf blights are caused by several pathogens and can be difficult to identify in the field. Alternaria leaf blight (*Alternaria dauci*) can be very serious. Symptoms appear as dark-brown to black necrotic lesions along the margins of the leaves and on the petioles. Symptoms first appear on the older foliage and then on younger leaves if warm, moist conditions persist. Long-beaked, multicelled conidia can be seen with the aid of a microscope on the leaves and petioles of diseased plants. Under a microscope, carrot early blight (*Cerocospora carotae*) can be differentiated from alternaria leaf blight by the very thin threadlike spores *C. carotae* produces on the lesions. Bacterial blight (*Xanthomonas campestris*) symptoms are slightly different from those of alternaria leaf blight in that the lesions are not as dark and may be surrounded by a yellow halo. Bacterial oozing may also be seen on the lesions present on the leaves and petioles. The bacterial exudates are particularly visible on the flower stalks of plants that have bolted. Alternaria leaf blight and bacterial blight are seedborne diseases that can be avoided by planting seed known to be disease free. Fungicides can be used for control of early blight and alternaria blight. Copper fungicides work best for bacterial blight, although this disease is rarely a serious problem.

The main symptoms of black root rot (*Alternaria radicina*) are black lesions on the base of the petioles. The lesions may extend down into the root, causing the characteristic "black crown." Crop rotation may reduce the spores in the soil; the spores are known to survive in the soil for more than 5 years without a host. Plowing to turn the spores under has been shown to reduce the incidence of this disease in fields with a history of black root rot. Fungicides can also be used for control but need to be directed at the canopy to protect the petioles and crown.

Two viruses affect carrots in California. Carrot motley dwarf is found in the cooler carrot-growing regions along the central coast. Infected plants appear stunted and have reddish tops. The disease is transmitted by aphids to newly planted fields from previously infected overwintering fields and can be controlled by avoiding planting near overwintering carrot fields. Carrot thin leaf is another aphid-vectored viral disease that can spread from infected volunteer carrots. Symptoms are the thin leaves that give the virus its name. Eliminating volunteer carrots reduces the chances of the virus spreading into newly planted fields.

**Nematodes.** The root knot nematode (*Meloidogyne* spp.), the primary nematode pest of carrots, causes stubbing, forking, and galling. It is found in all carrot-growing regions of California. Other nematode pests include the stubby root nematode (*Trichodorus* spp. and *Paratrichodorus* spp.) and the needle nematode (*Longidorus africanus*). Nematicides or soil fumigants are used to control nematodes. Soil fumigants applied by chemigation or injection into the soil may give other benefits such as weed and soilborne disease control. Crop rotation can also reduce these pests.

## HARVESTING AND HANDLING

Commercially grown carrots are harvested using self-propelled multirow harvesters. Some machines can harvest more than 1,000 tons (907 t) of carrots per day (about 30 semi-truck loads). The 4-row machines dig two beds 42 inches (105 cm) wide per pass, lift the roots using a system of belts, shear off the tops, and deposit the roots into a waiting truck or trailer. The carrots are then hauled to a shed for washing, grading, sizing, and

packing. In the Central Valley carrots are hauled a short distance, usually to sheds in Bakersfield, whereas carrots grown in the deserts may be hauled over 300 miles. The grower pays part of the freight to the shed. On average, 40 to 80 percent of all the carrots growing in the field are harvested and "packed out." Carrots that are damaged by the harvester or by insects or are diseased, deformed, or off-color are culled.

Carrots may be grown specifically for the cut-peeled carrot market, or culled carrots may be cut and peeled to the desired size. Harvesting carrots for the mini-carrot and cut-peeled market is difficult because of the high density of roots. During harvesting, excess dirt may be picked up, increasing the tare hauled to the shed. Dirt is also expensive to remove and dispose of at the shed. For bunched carrots, a small acreage of which is planted in California, the beds are undercut and the carrots are hand-sorted in the field. The green tops are bound with a wire twist tie, and the bunches are loaded onto flatbed trucks and hauled to the shed for washing and packaging. Careful handling of carrots during and after harvest prevents bruising, shatter-cracks, and tip breaks and prolongs storage life.

## POSTHARVEST HANDLING

Before storage, carrots are generally washed and hydrocooled in clean water with 100 ppm chlorine at pH 6.5 to 7.5 before being packed in plastic-lined bins. Research has shown, however, that if carrots are to be stored for an extended period, carrot quality is highest and postharvest losses lowest if they are stored with the tops on, unwashed, and in plastic-lined bins. Topping and handling during washing increases cracking and scuffing damage, which leads to increased rot. Unwashed storage has worked successfully with harvests from light, sandy soils. Soil type, harvest conditions, and local experience should prevail in handling and storage decisions.

Ideal storage conditions for carrots are 32°F (0°C) at 99 percent relative humidity (RH). Under these conditions, carrots have been stored successfully for more than 7 months with minimal losses (10 to 15 percent) due to dehydration and decay. At 33.8°F (1°C) and 98 percent RH, the conditions common in most storage, the maximum recommended storage is 5 months.

Carrots for the cut-peeled market are generally cut into 2-inch (5-cm) segments ("slugs"). These carrots may be held in plastic-lined bins prior to peeling and shaping and should have adequate air circulation and uniform temperature during storage to minimize decay and sprouting. Bunched carrots and forcing-type cut-peeled carrots are highly perishable, especially with tops intact. They must be thoroughly precooled to 32°F (0°C) and can be stored at this temperature at 99 percent RH for up to 2 weeks. Top icing, although not necessary with properly precooled carrots, is often used for bunched carrots to demonstrate that low temperature and high humidity existed during transit.

During storage and transportation, carrots should not be exposed to ethylene gas from propane-powered lift trucks or produce such as apples or pears. Ethylene induces the production of compounds that cause bitterness in carrots.

## POSTHARVEST DISORDERS

The most important storage decays of carrots are gray mold (*Botrytis* spp.), watery soft rot (*Sclerotinia* spp.), *Rhizopus* rot, bacterial soft rot (*Erwinia* spp.), and sour rot (*Geothrichum* spp.). Decay can be controlled by proper storage and handling to prevent mechanical injury (fluctuations in temperature during storage promotes water condensation and decay). Whiteness of the cut or peeled surface ("white blush"), common on fresh-cut carrots (cut-peeled, sticks, or coins), is caused by dehydration. Use sharp cutting blades and keep free moisture on work surfaces during packaging to prevent this disorder. A white, edible coating that reduces white blush has been developed that may be applied before packaging.

## SHIPPING CONTAINERS

Shipping containers for the various types of processed carrots are as follows. Topped: 50-lb carton/sack containing loose carrots or ten 5-lb film (cello) bags; 40-lb carton of 1-lb cello bags; 26-lb carton of bunched carrots; 25-lb carton of loose carrots; 24-lb carton of 1-lb cello bags; 15-lb carton of twenty 12-oz cello bags. Bunched: 26-lb carton/crate. Mini-carrots: 20-lb carton of 1-lb cello bags; 15-lb carton of twenty 12-oz cello bags. Fresh-cut: 18-lb carton of 1-lb or 2-lb cello bags; 9-lb carton of 1-lb cello bags.

## MARKETING

Carrots are shipped from California year-round. Shipments are highest from December to August. California produces about 85 percent of all carrots grown in the United States. Colorado, Florida, Michigan, Texas, and Washington are important carrot-producing states. Major carrot imports come from Canada and Mexico.



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