Carrot September 2024

PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

CONTENTS (Dates in parenthesis indicate when each topic was updated)

General Information (Section reviewed 09/24) **1**
Relative Toxicities of Pesticides Used in Carrot to Natural Enemies and Honey Bees (09/24) 1

Insects (Section reviewed 09/24) **2**
Aphids (09/24) 2
Crown and Root Aphids (09/24) 5
Flea Beetles (09/24) 7
Whiteflies (09/24) 9

Diseases (Section reviewed 03/24) **11**
Alternaria Leaf Blight (03/24) 11
Bacterial Leaf Blight (03/24) 14
Bacterial Soft Rot (03/24) 16
Black Rot (Black Crown) (03/24) 17
Carrot Motley Dwarf (03/24) 19
Carrot Thin Leaf (03/24) 20
Cavity Spot (03/24) 21
Cercospora Leaf Blight (03/24) 23
Cottony Soft Rot (03/24) 25
Diseases Caused by Phytoplasmas (03/24) 27
Powdery Mildew (03/24) 28
Root Dieback (Forking and Stubbing) (03/24) 30
Southern Blight (03/24) 32

Nematodes (02/24) **33**

Weeds (Section reviewed 04/24) **36**
Integrated Weed Management (04/24) 36
Special Weed Problems (04/24) 38
Common and Scientific Names of Weeds (04/24) 39
Susceptibility of Weeds in Carrot to Herbicide Control (04/24) 40
Weed Management for Organic Vegetable Production (04/24) 41
Herbicide Treatment Table (04/24) 45

Precautions for Using Pesticides **48**

An illustrated version of this guideline is available online at ipm.ucanr.edu/agriculture/carrot/

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- **Online**: ipm.ucanr.edu
- **UC Cooperative Extension:** County Offices
- **University of California**
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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you in making the best choices for an IPM program. Not all formulations or registered materials are mentioned. Always read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

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General Information

(Section reviewed 09/24)

RELATIVE TOXICITIES OF PESTICIDES USED IN CARROT TO NATURAL ENEMIES AND HONEY BEES (09/24)

Common name (trade name)	Mode of Action[1]	Selectivity[2] (affected groups)	General predators[3]	Parasites[3]	Honey bees [4]	Duration of impact to natural enemies[5]
beta-cyfluthrin (Baythroid XL)	3A	broad (insects)	H	H	I	moderate
carbaryl* (Sevin XLR Plus)	1A	broad (insects)	H	H	I	long
esfenvalerate (Asana XL)	3A	broad (insects)	M	H	I	moderate
flonicamid (Beleaf 50SC)	29	narrow (aphids)	L	L	III	short
imidacloprid (Admire Pro)	4A	narrow (sucking insects)	—	—	I	—
imidacloprid/beta-cyfluthrin (Leverage 360)	4A/3A	broad (insects)	H	H	I	moderate
insecticidal soap (M-Pede)	UN	broad (exposed insects)	L	L	III	short
malathion (Malathion 8 Aquamul)	1B	broad (insects)	H	H	I	moderate
methomyl* (Lannate SP)	3A	broad (insects)	H	H	I	moderate
thiamethoxam (Actara)	4A	narrow (sucking insects)	M/H	M/H	I	moderate
zeta-cypermethrin (Mustang)	3A	broad (insects)	M	M	I	moderate

H = high M = moderate L = low — = no information

I = Do not apply or allow to drift to plants that are flowering, including weeds. Do not allow pesticide to contaminate water accessible to bees, including puddles.

II = Do not apply or allow to drift to plants that are flowering, including weeds, except when the application is made between sunset and midnight if allowed by the label and regulations. Do not allow pesticide to contaminate water accessible to bees, including puddles.

III = No bee precaution, except when required by the label or regulations.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. For more information, see irac-online.org.

2 Selectivity: **broad** means the pesticide affects most groups of insects and mites; **narrow** means the pesticide affects only a few specific groups.

3 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific insecticide depends on factors including the application rate, environmental conditions, and life stages and species of parasite or predator

4 For more information, see *Bee Precaution Pesticide Ratings* (available online at ipm.ucanr.edu/beeprecaution).

5 Duration: **Short** means hours to days; **moderate** means days to two weeks; and **long** means many weeks or months.

* Permit required from county agricultural commissioner for purchase or use.

Acknowledgments: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M.L. and S.H. Dreistadt. 1998. Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control, ANR Publication 3386.

Insects

(Section reviewed 09/24)

APHIDS (09/24)

Bean aphid: *Aphis fabae*
Cowpea aphid: *Aphis craccivora*
Cotton (melon) aphid: *Aphis gossypii*
Green peach aphid: *Myzus persicae*
Honeysuckle aphid: *Hyadaphis foeniculi*
Willow-Carrot aphid: *Cavariella aegopodii*

Description of the Pest

In addition to the crown and root aphids, which are discussed separately, other species of aphids are found on carrot. These aphid species have soft bodies and vary in color, size, and shape. Winged aphids form under specific conditions of overcrowding or plant stress and disperse to other plants or fields. Species can be distinguished by color and examination of the cornicles, tubercles, and cauda using a hand lens.

- Bean aphid: A dark olive-green to black aphid with a dull appearance. Hairs on the cauda give it a bushy appearance. Winged and wingless forms have a similar appearance.
- Cowpea aphid: A dark olive-green to black aphid with a shiny appearance. A relative lack of hairs on the cauda gives it a more naked appearance compared to bean aphid. Winged and wingless forms have a similar appearance.
- Cotton (melon) aphid: Small to medium-sized and highly variable in color, ranging from lemon yellow to blackish green, often within the same colony. Color may change with temperature fluctuations, being lighter when the temperature is hotter.
- Green peach aphid: Medium-sized, uniformly pale green or pinkish with prominent cornicles. The frontal tubercles at the base of the antennae are very prominent and are convergent. This is the most common type of aphid found on carrot. Winged forms have a distinct dark patch on the abdomen.
- Honeysuckle aphid: Wingless forms are grayish green with dark features and may have a fine white wax dusting. Winged forms have a mottled green abdomen and a dark patch around the base of each cornicle.
- Willow carrot aphid: Pale green wingless forms with elongate oval bodies and a second tail-like process called the supracaudal process. Winged forms have a black head and thorax with a pale green abdomen. The antennae are black. The legs are pale in color and black at the tips. The cornicles are somewhat swollen near the tip.

Damage

Aphids that feed on the tops of carrots are rarely of concern due to the removal of tops at harvest. Exceptions can occur if aphids transmit viruses during early stages of development. Virus infected carrots typically have curled or distorted leaves that can lead to stunting. Most aphid species can transmit one or more different viruses. Some of the more serious viruses include carrot motley dwarf, carrot red leaf, and parsnip yellow fleck that are transmitted by willow carrot aphid.

Management

Biological Control

Species of aphids can be controlled by predators, parasites, or entomopathogenic fungi. Common aphid predators include green lacewing, lady beetles, and syrphid fly larvae. Many predators are commercially available but efficient release rates are not known.

Parasitized aphids can be identified by their tan color and bloated appearance. Bean aphid is attacked by a very prolific parasitic wasp, *Lysiphlebus testaceipes.* Cowpea aphid is commonly attacked by *Lysiphlebus* spp. and *Diaeretiella* spp. Several parasites of cotton aphid and green peach aphid are present in California and can provide effective control. Little is known about parasites of honeysuckle aphid or willow carrot aphid.

Bean aphids and green peach aphids are also attacked by a fungal disease that leaves the aphid body flattened and with the appearance of being glued to the leaf.

Cultural Control

Field sanitation is important in reducing the number of aphids in and around carrots. Sanitation is also important in slowing the spread of the viruses that willow carrot aphid vectors. Disc all crop residues into the soil as soon as harvest is complete. Keeping fields, ditch banks, and fence lines weed-free may also help to reduce virus inoculum.

Carrots planted next to aphid-infested cotton or melon are at risk of becoming infested with cotton aphid particularly in fall following cotton defoliation or termination of the melon crop. Carrots should be planted a safe distance from both, if possible.

Organically Acceptable Methods

Use biological and cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

Monitor fields for aphids weekly during spring and summer by examining the upper and lower surfaces of leaves. Also, look for evidence of predators and parasitoids and their impact on aphid populations.

No treatment thresholds for aphids in carrot have been established.

For bean aphid, cowpea aphid, cotton aphid, and willow carrot aphid, insecticide treatments are not effective in preventing virus transmission and these aphids rarely cause economic damage through direct feeding.

For honeysuckle aphid, insecticide treatment is generally not advisable as economic damage is rare.

For green peach aphid, small colonies occasionally develop on carrot leaves and may reach treatable levels, but no treatment thresholds for green peach aphid on carrots have been established. Green peach aphid has developed a high level of resistance to many pesticides and may be hard to control.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 09/24

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.

A. IMIDACLOPRID
(Admire Pro-foliar) 1.2 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Thorough, uniform coverage is important for good control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

B. IMIDACLOPRID/BETA-CYFLUTHRIN
(Leverage 360) 2.8 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A/3A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

C. THIAMETHOXAM
(Actara) 1.5–3 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

D. ZETA-CYPERMETHRIN
(Mustang) 3.4–4.3 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. FLONICAMID
(Beleaf 50SG) 2–2.8 fl oz 12 3
MODE-OF-ACTION GROUP NUMBER[1]: 29

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. For more information, see irac-online.org.

CROWN AND ROOT APHIDS (09/24)

Hawthorn carrot aphid: *Dysaphis crataegi*
Hawthorn/parsley aphids: *Dysaphis foeniculus*, *Dysaphis apiifolia*
Tulip bulb aphid: *Dysaphis tulipae*

Description of the Pest

These aphids form colonies near the top of the root and at the base of the stems, as compared to aphids that feed on the foliage and are addressed separately in this publication. They occasionally form colonies on the root slightly below ground. All are similar in appearance, with the wingless forms being pale yellow to gray green and covered with a powdery wax.

The tulip bulb aphid is covered with a white waxy powder, while the wax covering the hawthorn parsley aphid is grayish white. The hawthorn carrot aphid is yellowish gray to greenish gray with a very light dusting of wax.

All three species, when present, are usually attended by ants. The presence of ants around the base of the plants is usually a good clue to the presence of these aphids.

Damage

These aphids occur infrequently and only occasionally cause injury. High numbers may stunt growth, but more serious is that the tops may be weakened by their feeding and break off during harvest, leaving the carrot in the ground.

Management

Biological Control

Because of their location near and below the soil line, predators and parasitoids have a difficult time finding these aphids. Ants that tend to aphids also discourage the activity of predators and parasites.

Cultural Control

Sanitation and crop rotation to nonhost crops are important in reducing the buildup of these aphids and their injury.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

No treatment thresholds have been established for these aphids.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 09/24

Not all registered pesticides are listed**. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.

A. IMIDACLOPRID
(Admire Pro-foliar) 1.2 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Thorough, uniform coverage is important for good control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

B. IMIDACLOPRID/BETA-CYFLUTHRIN
(Leverage 360) 2.8 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A/3A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

C. MALATHION
(Malathion 8 Aquamul) 1–1.25 pt 24 7
MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. ZETA-CYPERMETHRIN
(Mustang) 3.4–4.3 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. THIAMETHOXAM
(Actara) 1.5–3 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. For more information, see irac-online.org.

FLEA BEETLES (09/24)

Palestriped flea beetle: *Systena blanda*
Potato flea beetle: *Epitrix cucumeris*

Description of the Pest

Flea beetle adults are 0.12 inch (3 mm), shiny beetles with enlarged hind legs that allow them to jump like fleas. The palestriped flea beetle has a broad white stripe down each brown wing. The potato flea beetle is a uniform black color.

The larvae live in the soil, are slender, whitish, and about 0.25 inch (6 mm) long when mature.

Damage

Adult flea beetles do most of their damage by feeding on the undersides of leaves, leaving small pits or irregularly shaped holes on the leaves. Large populations can kill or stunt seedlings. Older plants rarely suffer economic damage although their older leaves may be damaged.

In the Imperial and San Joaquin Valleys, larvae are known to cause serious damage by feeding on the roots. Wounds on the surface of the taproot often follow a straight or curved line down on side of the root. This damage is easily confused with cavity spot symptoms. Cavity spot lesions are elliptical and more sunken, are more randomly scattered on the root surface, and tend to be more concentrated on the upper third of the root.

Management

Cultural Control

Remove weeds along field margins and deeply disk plant residue in infested fields after harvest.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

Check newly emerged seedlings twice weekly for flea beetle damage until plants are well established. Relatively low populations can cause economic damage when plants are in the cotyledon or first-leaf stages. Apply insecticides if you find several damaged rows; spot treatment of outside rows or borders may be sufficient. Baits are not effective.

Once plants have several true leaves, they can tolerate several beetles per plant without damage. Older plants are even more tolerant. Insecticide treatment should rarely be required, but if it is, one application should suffice. However, chemical treatment may disrupt biological control of aphids and whiteflies. Encourage buildup of beneficial insects by avoiding the use of nonselective pesticides and by protecting their habitat.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 09/24

Not all registered pesticides are listed**. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.

A. ESFENVALERATE
(Asana XL) 5.8–9.6 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Lower rate should suffice. Highly toxic to bees: do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B. CARBARYL*
(Sevin XLR Plus) 0.5–1 qt 12 3
MODE-OF-ACTION GROUP NUMBER[1]: 1A

C. THIAMETHOXAM
(Actara) 1.5–3 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredient or using more than one application method in the same season.

D. ZETA-CYPERMETHRIN
(Mustang) 3.4–4.3 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. BETA-CYFLUTHRIN
(Baythroid XL) 2.8 fl oz 12 0
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Ground application with 30 gallons per acre preferred but 10 gal water/acre by air is acceptable. Use a silicone surfactant. Highly toxic to bees: do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. For more information, see irac-online.org.

* Permit required from county agricultural commissioner for purchase or use.

WHITEFLIES (09/24)

Greenhouse whitefly: *Trialeurodes vaporariorum*
Iris whitefly: *Aleyrodes spiraeoides*
Silverleaf whitefly: *Bemisia argentifolii*

Description of the Pest

Whiteflies are small flying insects that are about 0.04 inch (1 mm) long. The body and wings of adults are covered with a fine whitish powdery wax that is opaque in appearance. Whiteflies colonize the underside of leaves; adults and eggs are commonly found on the lower surface of younger leaves and the scalelike nymphal stages on somewhat older leaves.

Distinguishing whitefly species is difficult; use a hand lens to examine both immatures and adults. Adult Silverleaf whiteflies, sometimes called sweetpotato whiteflies, hold their wings somewhat vertically tilted like the peaked roof of a house, instead of flat over their bodies like the greenhouse whitefly. During the last part of the fourth larval stage, often called the pupa, whiteflies develop red eyes and stop feeding. The pupal stage is the stage that is easiest to identify silverleaf whitefly; pupae have no waxy filaments around their edges as do most other species of whiteflies.

Damage

Extremely dense populations of silverleaf whitefly may immigrate into late-August or September plantings of carrots in the low deserts of southern California and damage seedlings. In light to moderate infestations, leaves show no distinctive symptoms as a result of whitefly feeding; however, copious quantities of honeydew are deposited on leaves, resulting in a shiny, sticky appearance.

Management

Whiteflies can be very difficult to control with insecticides. Natural or introduced biological methods provide the best long-term solution to keeping whitefly numbers at a minimum along with reducing host plants in areas of heavy infestation. If you treat for silverleaf whitefly, make applications before pests build up and contaminate carrot tops with honeydew.

Biological Control

Several parasitic wasps, including species in the *Encarsia* and *Eretmocerus* genera, control whiteflies. Whitefly nymphs are also preyed upon by bigeyed bugs, green lacewing larvae, brown lacewing larvae and lady beetles. Encourage buildup of beneficial insects by avoiding the use of nonselective pesticides and by protecting their habitat.

Cultural Control

Remove field bindweed and other weeds in and adjacent to the crop field as well as crop residues. Host-free periods are valuable for controlling several of the whitefly species.

Organically Acceptable Methods

Use biological controls, cultural controls, and soap sprays in a certified organic crop.

Monitoring and Treatment Decisions

Carrots are not a preferred host of whiteflies and in some areas treatment with insecticides is rarely justified. Where silverleaf whitefly is a chronic problem, a treatment with imidacloprid at planting will effectively control whiteflies during the critical period of stand establishment. If treatment is not applied at planting, occasionally dense colonies of silverleaf whitefly nymphs can necessitate treatment of bunching carrots to prevent honeydew and sooty molds from severely contaminating the carrot tops.

For foliar treatment, combinations of a pyrethroid insecticide (mode-of-action group 3A) with methomyl provide superior control over applications of a single insecticide. Rotate pyrethroid treatments with a treatment of insecticidal soap to help slow development of insecticide resistance. Insecticidal soaps control all immature stages of whiteflies, including eggs, whereas the other insecticides control first instar nymphs and adults only; thus,

treatment timing is critical.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 09/24

Not all registered pesticides are listed**. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.

A. IMIDACLOPRID
(Admire Pro - Soil) 4.4–10.5 fl oz 12 21
MODE-OF-ACTION GROUP NUMBER1: 4A
COMMENTS: Apply at planting to control migrating whitefly adults during stand establishment. Has minimal effect on natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

B. IMIDACLOPRID / BETA-CYFLUTHRIN
(Leverage 360) 2.8 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER1: 4A/3A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

C. INSECTICIDAL SOAP
(M-Pede)# 1% solution or less 12 0
MODE-OF-ACTION GROUP NUMBER1: UN
COMMENTS: This material has no residual activity and requires frequent applications and thorough coverage. Provides poor control of adults.

D. METHOMYL*
(Lannate SP) 0.5–1 lb 48 1
MODE-OF-ACTION GROUP NUMBER1: 1A
COMMENTS: Tank mix with esfenvalerate product.

D. ESFENVALERATE
(Asana XL) 5.8–9.6 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER1: 3A
COMMENTS: Tank mix with methomyl product. Apply as needed for control, but do not exceed 0.5 lb a.i. (3 qt esfenvalerate/acre per season). Use ground application only. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. THIAMETHOXAM
(Actara) 3.0–4.0 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER1: 4A
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

If grown for seed, review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

1 Group numbers for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. For more information, see irac-online.org.

Acceptable for use on certified organic crops.

Diseases

(Section reviewed 03/24)

ALTERNARIA LEAF BLIGHT (03/24)

Pathogen: *Alternaria dauci*

SYMPTOMS AND SIGNS

Alternaria leaf blight initial symptoms typically begin on older leaves as brown spots surrounded by a yellow margin. At later stages of disease development, dark brown to black irregularly shaped necrotic lesions develop on leaf blades and petioles. Leaves can be killed when foliar spots grow together or by lesions that develop on petioles. At advanced stages of disease development, leaves will have a scorched appearance. This disease weakens tops that then break during mechanical harvest leading to roots left in the ground and yield loss. The pathogen also causes damping-off of carrot seedlings.

COMMENTS ON THE DISEASE

The pathogen, *Alternaria dauci*, is seedborne and survives on and is spread with carrot seed. It can also survive on volunteer carrots and crop debris, but once the crop residue decomposes, the fungus dies. Spores are dispersed in air and splashing water and disease is favored by leaf wetness either due to rain or overhead irrigation. The optimum temperature for growth and infection is 82°F with some infection occurring at temperatures as low as 57°F and as high as 95°F.

MANAGEMENT

Cultural Control

Planting *Alternaria*-indexed seed or treating seed in a hot water dip is very important. Turn under carrot residue by tillage or plowing to hasten decomposition of debris, because the pathogen only survives in soil, in infected carrot residue. Practice 2-year rotations and avoid continuous carrot culture. Do not plant new fields near existing fields with blight symptoms. Differences in susceptibility exist among commercial cultivars.

Most growers use sprinkler irrigation throughout the growing season. If possible, the use of furrow irrigation may aid in disease reduction.

Organically Acceptable Methods

Use cultural controls, hot water dips, and foliar sprays of Serenade ASO are acceptable in a certified organic crop.

Monitoring and Treatment Decisions

Seed treatments may reduce *Alternaria dauci*. Assay the seed and if pathogen is found, treat. If seed is not treated, apply fungicides when the first blight symptoms appear, at biweekly intervals, or when conditions are favorable for disease development.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SEED TREATMENT

A. HOT WATER DIP#
COMMENTS: Soak seed in hot water (122°F; 50°C) for 25 minutes. Do not soak longer or seed could be damaged.

FOLIAR TREATMENT

A. AZOXYSTROBIN
(Quadris) 9.0–15.5 fl oz 4 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than four foliar applications of strobilurin fungicides per crop.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
B. CHLOROTHALONIL (Bravo Weather Stik)	1.5–2 pt	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M5)			
COMMENTS: Repeat applications at 7- to 10-day intervals if necessary to maintain control. After completion of the REI, follow safety precautions detailed on the label for 6.5 days.			
C. IPRODIONE (Rovral 4F)	1–2 pt	24	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)			
COMMENTS: Do not make more than four applications of iprodione per season.			
D. PYRACLOSTROBIN (Cabrio EG)	8–12 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than three applications of strobilurin fungicides per crop.			
E. PYRACLOSTROBIN/FLUXAPYROXAD (Merivon)	4–5.5 fl oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)/Succinate dehydrogenase inhibitor (7)			
COMMENTS: Begin applications prior to disease development and continue on a 7- to 14-day interval if conditions are conducive for disease development. Use the higher rate and shorter interval when disease pressure is high. Do not make more than two (2) sequential applications before alternating to a labeled non-group 7 or non-group 11 fungicide.			
F. TRIFLOXYSTROBIN (Flint Extra)	2–2.9 oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
COMMENTS: To limit potential for resistance development do not apply more than three sequential applications or a total of four applications of all strobilurins per season. Do not apply more than 11.5 oz/acre per year.			
G. PENTHIOPYRAD (Fontelis)	16–30 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)			
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use higher rate and a shorter interval when disease pressure is high.			
H. BOSCALID (Endura)	4.5 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)			
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use a shorter interval when disease pressure is high. To limit the potential for resistance development do not apply more than two sequential applications before rotating to a labelled fungicide with a different mode of action.			
I. POLYOXIN D ZINC SALT (Ph-D)	6.2 oz	4	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Cell wall synthesis (19)			
COMMENTS: Begin applications preventively when conditions are favorable for disease development. May be applied through overhead sprinkler irrigation.			
J. BACILLUS SUBTILIS (Serenade ASO)#	2–4 qt	4	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Bacterial (BM02)			
COMMENTS: Serenade ASO is most effectively used in a preventive disease management program. Serenade ASO is applied with chemigation equipment.			

** Apply with enough water to provide complete coverage.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on certified organic crops.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

BACTERIAL LEAF BLIGHT (03/24)

Pathogen: *Xanthomonas campestris* pv. *carotae*

SYMPTOMS AND SIGNS

Bacterial leaf blight is often first noticed in fields as brown areas about 3 to 4 feet in diameter. Leaf symptoms appear as irregular brown water-soaked spots surrounded by a yellow halo, often beginning on the leaf margins. Spots grow together and result in leaf death and dark brown streaks develop on leaf petioles. Floral parts may also be blighted. A sticky amber-colored bacterial exudate, which is a diagnostic sign of the disease, may be present on leaves or observed flowing downward on petioles and flower stalks. Infected flower clusters, umbels, may be completely blighted.

COMMENTS ON THE DISEASE

Xanthomonas campestris pv. *carotae* is seedborne and is spread with carrot seed. The bacteria also survive in carrot debris but cannot survive in the soil in the absence of debris. Rain or sprinkler irrigation is required for optimum disease development. Optimum temperatures are between 77° and 86°F; infection does not occur below 65°F. Plant-to-plant spread occurs with splashing water during rainfall, sprinkler irrigation, and may even occur during periods of heavy dews.

In most carrot-growing areas, bacterial blight does not warrant control. In a few areas, such as the Antelope and Cuyama Valleys, severe outbreaks may occur.

MANAGEMENT

Cultural Control

Plant *Xanthomonas*-indexed seed or treat seed in a hot water dip. Use of furrow irrigation rather than sprinklers may aid in reducing disease pressure. Turn under carrot residue to hasten decomposition. Avoid continuous carrot culture and practice a 2- to 3-year crop rotation scheme.

Organically Acceptable Methods

Use cultural controls, hot water dips, and sprays of certain copper sulfate formulations in a certified organic crop.

Monitoring and Treatment Decisions

Assay seed and treat if pathogen is found. Foliar treatments occasionally necessary if rainy weather persists.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SEED TREATMENT

A. HOT WATER DIP#
COMMENTS: Soak seed in hot water (126°F; 52°C) for 25 minutes.

FOLIAR TREATMENT

A. COPPER SULFATE# — Label rates — See label — 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M1)
COMMENTS: Repeat applications at 7- to 14-day intervals, if necessary, to maintain control. Not all copper compounds are approved for use in organic production so be sure to check individual products.

B. COPPER HYDROXIDE (Champ WG)# — Label rates — 48 — —
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M1)

C. COPPER OCTANOATE# (Cueva) — Label rates — 4 — 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M1)

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on certified organic crops.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

BACTERIAL SOFT ROT (03/24)

Pathogen: *Pectobacterium* (=*Erwinia*) *carotovorum* ssp. *carotovorum*

SYMPTOMS AND SIGNS

Bacterial soft rot is recognized as a soft, watery, and slimy decay of the carrot root, not associated with any fungal growth and accompanied by a foul odor. The decay rapidly consumes the core of the carrot, often leaving the epidermis intact. Aboveground symptoms include a general yellowing, wilting, and collapse of the foliage. Soft rot can occur in the field and during storage.

COMMENTS ON THE DISEASE

Pectobacterium carotovora is a common soilborne bacterium that attacks a wide range of fruits and vegetables. The bacterium enters carrots through various kinds of wounds. In the field, soft rot is most often associated with warm temperatures and extended periods of standing water resulting from poor drainage, low areas, or leaky irrigation pipes. Mature carrot roots are most susceptible to infection.

MANAGEMENT

In the field, maintain good drainage and avoid practices that could wound roots. Avoid prolonged irrigation of mature carrots during warm months of the year. In the packinghouse, handle carrots carefully to avoid bruising and store them under cool conditions. Chlorine added to the wash water helps to eliminate the soft rot bacteria from carrot surfaces.

BLACK ROT (BLACK CROWN) (03/24)

Pathogen: *Alternaria radicina*

SYMPTOMS AND SIGNS

Black rot of carrots caused by *Alternaria radicina* starts in the crown with black lesions on the base of the petioles. The lesions may extend down into the root, causing the characteristic "black crown". The upper part of the carrot root will have a dry, dark rot, which occasionally may extend into the lower part of the carrot root. Affected tops often break during mechanical harvesting leaving the roots in the ground and reducing yields. Although all crops growth stages can be infected, older, mature carrots are particularly susceptible. Black rot can also be a problem in storage.

Under certain conditions, the fungus also can cause a leaf blight, which is characterized by dark brown lesions along the leaf margins. The fungus can also cause a pre- and postemergence damping-off of carrot seedlings.

COMMENTS ON THE DISEASE

Alternaria radicina is seedborne and may be spread on carrot seed. The fungus is favored by sprinkler irrigation or rainy weather and high temperatures, which may predispose tissue to infection. It also survives in carrot debris and in the soil for several years. Black rot is important only in certain areas or regions in California. It is common in coastal mountain valleys, such as the Cuyama Valley.

MANAGEMENT

Cultural Control

Plant *Alternaria*-indexed seed or treat seed in a hot water dip; this is especially important in fields where black rot has not been identified or carrots have not been grown.

Furrow rather than sprinkler irrigation may reduce disease development. Crop rotation is highly recommended to prevent buildup of the fungus in the soil. Deep tillage may provide some control by burying inoculum of the fungus away from the carrot crown.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

Assay your seed, if pathogen is found, treat the seed. Foliar applications of fungicides to control black rot are marginally effective.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SEED TREATMENT

A. HOT WATER DIP#
COMMENTS: Soak seed in hot water (122°F; 50°C) for 25 minutes. Do not soak longer or seed could be damaged.

FOLIAR TREATMENT

A. AZOXYSTROBIN
(Quadris) 9.0–15.5 fl oz 4 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than four foliar applications of strobilurin fungicides per crop.

B. CHLOROTHALONIL
(Bravo Weather Stik) 1.5–2 pt 12 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M5)
COMMENTS: Repeat applications at 7- to 10-day intervals if necessary to maintain control. After completion of the REI, follow safety precautions detailed on the label for 6.5 days.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

C. IPRODIONE
(Rovral 4F) 1-2 pt 24 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Do not make more than four applications of iprodione per season.

D. PYRACLOSTROBIN
(Cabrio EG) 8–12 oz 12 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than three applications of strobilurin fungicides per crop.

E. TRIFLOXYSTROBIN
(Flint Extra) 2–2.9 oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: To limit potential for resistance development do not apply more than three sequential applications or a total of four applications of all strobilurins per season. Do not apply more than 11.5 oz/acre per year.

F. *BACILLUS SUBTILIS*
(Serenade ASO)# 2–4 qt 4 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Bacterial (BM02)
COMMENTS: Serenade ASO is most effectively used in a preventive disease management program. Serenade ASO is applied with chemigation equipment.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on certified organic crops.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

NA Not applicable

CARROT MOTLEY DWARF (03/24)

Pathogens: The luteovirus *Carrot redleaf virus* (CRLV) and the umbravirus *Carrot mottle virus* (CMoV)

SYMPTOMS AND SIGNS

Carrot motley dwarf is caused by the combined infection of carrots by two viruses *Carrot redleaf virus* and *Carrot mottle virus*. Plants infected in the seedling stage will be severely stunted and yellow to red in color. Plants appear as if they are suffering a nutritional deficiency. Roots may also be stunted. When plants are infected at later stages of growth, symptoms are inconspicuous, plants may or may not have stunted growth, but some leaves will be red or yellow, or a combination of red and yellow. Some leaves on infected plants may remain green.

COMMENTS ON THE DISEASE

Carrot motley dwarf primarily occurs in the cooler carrot production areas of California, such as in the Salinas Valley and in the Ventura area and has been observed in the San Joaquin Valley only in spring carrots. It is not known to occur in the Imperial Valley growing regions. In some years, spring carrots are severely affected.

Carrot redleaf virus and *Carrot mottle virus* are transmitted from plant to plant only by the willow carrot aphid, *Cavariella aegopodii*. Both viruses are carried together by the aphid and are then transmitted to plants as the aphid feeds. Once aphids acquire the viruses, they transmit them for the remainder of their lives. Disease development is associated with nearby infected carrot fields and willow carrot aphids. The host range of the carrot motley dwarf viruses is relatively narrow and largely limited to carrot, parsley, and cilantro. The host range of willow carrot aphid is also narrow. Cilantro is not an aphid host, and although it is a virus host, it is not a likely source for subsequent virus spread. Carrots appear to be the best host for both viruses and the aphid vector, and overwintered carrots are the most important inoculum source for subsequent spring carrot motley dwarf development.

MANAGEMENT

Cultural Control

Some genetic resistance, but not immunity, is available in certain carrot cultivars. Typically, Danvers types are most susceptible whereas Imperator types are most resistant. Control in coastal areas also can be achieved by avoiding overwintering carrots. As overwintered carrots are the most important source of spring inoculum, attempts should be made to eliminate overwintered fields. Insecticide applications in overwintering fields may offer some control of vector populations. If overwintered carrots are present, avoid planting early spring (December–January) carrots within close proximity (about 5 miles).

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Treatment Decisions

Insecticides are ineffective for control of virus transmission to new crops.

CARROT THIN LEAF (03/24)

Pathogen: The potyvirus, *Carrot thin leaf virus* (CTLV)

SYMPTOMS AND SIGNS

Symptoms on plants infected with *Carrot thin leaf virus* can vary. In general, leaflets appear thinner than normal, giving the plant an overall unusual appearance. Some leaves may have leaflets that are distorted and show a mosaic pattern. Leaflets of plants infected at a young stage may be extremely thin, hence the name of the virus. The virus has not been shown to cause yield losses in California.

COMMENTS ON THE DISEASE

Carrot thin leaf virus is only transmitted from plant to plant by aphid vectors. Aphids transmit the viruses during the probing phase of aphid visitation to plants; transmission does not occur during aphid feeding. Aphids only retain the ability to transmit these viruses for very short periods of time (minutes to a few hours). Thus, spread is often very rapid and occurs in local areas of a field. Many aphid species can spread *Carrot thin leaf virus*. Field spread of *Carrot thin leaf virus*, and potyviruses in general, occurs when aphid activity in fields is high.

Carrot thin leaf virus has a very limited plant host range; in nature it seems to be largely limited to carrots. In California, carrot thin leaf is primarily found in the Central Valley, mostly in the lower San Joaquin Valley carrot production area. Some fields have been found to have a significant incidence of carrot thin leaf but have not suffered economic loss. However, in Washington State, where it sometimes coinfects plants with other carrot viruses, disease losses can result. *Carrot thin leaf virus* over summers in volunteer carrots that survive from previous carrot plantings.

MANAGEMENT

Cultural Control

No cultivar resistance is known. A likely cultural control strategy would be to eliminate volunteer carrots during the late summer as newly planted seedlings are emerging; aphid activity is high at this time, and the virus can be spread to new fields.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Treatment Decisions

There are no effective pesticide strategies. Insecticides directed at controlling the aphid vectors are ineffective because they cannot kill the aphids before transmission occurs.

CAVITY SPOT (03/24)

Pathogens: *Pythium sulcatum*, *Pythium violae*

SYMPTOMS AND SIGNS

Cavity spot is characterized by small, sunken, elliptical to irregularly shaped lesions on the surface of carrot taproots. Individual lesions are usually less than 0.5 inch (1.3 cm) in diameter, but can be much larger, especially on processing varieties. Infections occur anywhere along the taproot, but lesions tend to be more abundant on the upper third of the root. Lesions become dark and increase in size as carrot roots mature.

COMMENTS ON THE DISEASE

The disease is favored by cool soil temperatures and excessive soil moisture due to poor drainage, low spots in the field, or rains. The incidence of the disease is probably dependent on the number of thick-walled oospores (overwintering spores) in the soil. *Pythium sulcatum* and *P. violae* also cause lesions on alfalfa roots. Infections of other hosts such as celery, black-eyed peas, wheat, cucumber, beets, and other plants, including weeds, may not result in symptoms.

MANAGEMENT

Cultural Control

Practice 3- to 4-year crop rotations with crops other than alfalfa. Do not over-irrigate. Harvest carrots soon after they mature because older carrots are more susceptible to infection. Some sources of genetic resistance have been identified but no commercially available cultivars are resistant.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Treatment Decisions

Apply fungicides to fields with a history of cavity spot.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED: 11/23			

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. MEFENOXAM
(Ridomil Gold SL) — See comments — 48 — 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)
COMMENTS: For in season applications, apply Ridomil Gold SL on a 14- to 21-day interval, 0.25 to 0.5 pt/acre in water as side dress when furrow irrigation is used. Refer to the Ridomil Gold SL label for use directions for chemigation. Do not exceed 2.8 pt/acre per crop season.

B. FENAMIDONE
(Reason 500SC) — 8.2 fl oz — 12 — 14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Alternate with a mefenoxam fungicide such as Ridomil Gold SL. Apply at a 14- to 21-day interval. When applying with ground equipment, direct spray to the base of the plant and follow immediately with 0.25–1 inch of irrigation to promote movement of material into the root zone.

C. CYAZOFAMID
(Ranman 400SC) — 6 fl oz — 12 — 14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Ubiquinone reductase, Qi site (21)
COMMENTS: Do not apply more than 5 sprays of Ranman per crop. Rotate with a fungicide with a different mode of action.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

D. FLUOPICOLIDE
(Presidio) 4 fl oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Mitosis and cell division (43)
COMMENTS: Do not make more than 3 total applications of presidio per year and do not make 2 sequential applications. For foliar applications, Presidio must be tank mixed with a labelled rate of another fungicide active against the target pest.

E. METAM SODIUM*
(Vapam HL) Label rates See label NA
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-Site Activity (M03)

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

* Permit required from county agricultural commissioner for purchase

NA Not applicable

CERCOSPORA LEAF BLIGHT (03/24)

Pathogen: *Cercospora carotae*

SYMPTOMS AND SIGNS

Cercospora blight can occur on any above ground carrot tissue. Symptoms appear as small, circular, tan to brown lesions, and curled leaf margins. The tan to brown lesions initially surrounded by a chlorotic halo often enlarge into brown necrotic spots. As the disease progresses, the leaflets become yellowed and curl at the margins. Lesions on leaf petioles, stems, and flower parts are usually elliptical and dark brown. Under heavy disease pressure, severe loss of foliage may occur eventually leading to yield losses.

COMMENTS ON THE DISEASE

Cercospora blight is usually of minor importance in California but often occurs in coastal carrot-growing regions. *Cercospora carotae* can be seedborne, but also overwinters on plant debris or in the soil. It can also survive on wild carrots. Infection occurs over a wide range of temperatures with an optimum at 82°F.

MANAGEMENT

Cultural Control

Use disease-free seed or apply fungicides to seed before planting. After harvest if the disease was present ensure crop debris is destroyed by plowing under crop residue and doing a 2- to 3-year crop rotation. Use commercially available resistant varieties.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

In fields with a history of Cercospora leaf blight, start fungicide applications when conditions are conducive to disease development or when disease is observed.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED: 11/23			
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.			
AFTER PLANTING			
A. AZOXYSTROBIN			
(Quadris)	9.0–15.5 fl oz	4	0
MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)			
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than four foliar applications of strobilurin fungicides per crop.			
B. CHLOROTHALONIL			
(Bravo Weather Stik)	1.5–2 pt	12	0
MODE-OF-ACTION GROUP NAME (NUMBER1): Multisite contact (M5)			
COMMENTS: Repeat applications at 7- to 10-day intervals if necessary to maintain control. After completion of the REI, follow safety precautions detailed on the label for 6.5 days.			
C. COPPER HYDROXIDE#	Label rates	48	—
MODE-OF-ACTION GROUP NAME (NUMBER1): Multisite contact (M1)			
COMMENTS: Repeat applications at 7- to 14-day intervals, depending on disease severity.			
D. PYRACLOSTROBIN			
(Cabrio EG)	8–12 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)			
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than three applications of strobilurin fungicides per crop.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
E. TRIFLOXYSTROBIN			
(Flint Extra)	2–2.9 oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)			
COMMENTS: To limit potential for resistance development do not apply more than three sequential applications or a total of four applications of all strobilurins per season. Do not apply more than 11.5 oz/acre per year.			
F. PENTHIOPYRAD			
(Fontelis)	16–30 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitor (7)			
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use higher rate and shorter interval when disease pressure is high.			
G. BOSCALID/PYRACLOSTROBIN			
(Pristine)	8–10.5 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitor (7)/Quinone outside inhibitor (11)			
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use higher rate and shorter interval when disease pressure is high. Do not use more than 63 oz/A/year. Rotate with a different mode of action fungicide after every application to limit the potential for resistance development.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

Acceptable for use on certified organic crops.

COTTONY SOFT ROT (03/24)

Pathogen: *Sclerotinia sclerotiorum*

SYMPTOMS AND SIGNS

Sclerotinia infection may occur at any stage of growth, and extensive root decay will occur before symptoms of wilt and collapse appear on the above ground of the plant. Infection is always accompanied by a characteristic cottony, white mycelium that appears on the surface of the infected tissues, usually near the soil line. On or inside the white mycelium appear black, round to irregular-shaped structures (sclerotia), which are about 0.1 to 0.4 inch (0.3–1 cm) in length. Sclerotia are survival structures of the fungus.

COMMENTS ON THE DISEASE

Cottony soft rot is favored by wet, cool weather, when soil temperatures are 55° to 70°F. During prolonged wet, cool conditions, the fungus can produce airborne spores. However, infections resulting from soilborne inoculum are more common in most parts of California. Moist soils are necessary for fungal activity, but once infection is established, moisture from the carrot root tissue is sufficient to maintain fungal growth. The disease can also occur in storage carrots from infections that initiated in the field, from uncleaned pallet boxes, or from contamination in storage.

MANAGEMENT

Cultural Control

Deep plowing once per year to bury sclerotia 8 to 10 inches into the soil will reduce disease incidence, but not eliminate it completely because spores may be blown in from other fields. A 2-year rotation to cereals, corn, or cotton will also help reduce sclerotia numbers in the soil. Trimming the sides of the foliage after the canopy closes and effective weed control may provide a less favorable environment for disease development by increasing ventilation between rows. Ensure proper storage conditions with near freezing temperatures, high relative humidity, and proper air movement.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Monitoring and Treatment Decisions

Begin applications when disease first appears, and conditions favor disease development.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. BOSCALID
(Endura) 7.8 oz 12 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use a shorter interval when disease pressure is high. To limit the potential for resistance development do not apply more than two sequential applications before rotating to a labelled fungicide with a different mode of action.

B. FLUAZINAM
(Omega 500F) 16 fl oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Uncouplers of oxidative phosphorylation (29)
COMMENTS: Make the initial application approximately 45 days prior to harvest or earlier if disease appears. If required, a second application can be made 14 days after the initial application. Apply in 30 to 50 gallons of water per acre as a directed band spray over the crop. DO NOT make more than 4 applications at the rate of 16 fl oz of Omega 500F per crop cycle.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

DISEASES CAUSED BY PHYTOPLASMAS (03/24)

Pathogens: Beet leafhopper-transmitted viresence agent, Aster yellows phytoplasma

SYMPTOMS AND SIGNS

Beet Leafhopper-Transmitted Viresence Agent

Leaves of infected plants are reddish purple with mild chlorosis. Infected plants often bolt prematurely. Flower parts are malformed; petals that would normally be white are green, and the flowers proliferate to form multiple, compound, leafy umbels. Diseased plants have unmarketable roots that are thin, woody, and hairy.

Aster Yellows Phytoplasma

Leaves of infected plants are twisted, stunted, and yellow. Leaflets may be reduced to short scales. Flower parts are severely distorted and malformed; umbels are stunted and yellow green. Most infected plants develop a dense cluster of dwarfed, chlorotic, upright, adventitious shoots. Infected plants have long, thin roots with increased lateral rootlet development.

COMMENTS ON THE DISEASE

The beet leafhopper-transmitted virescence agent is transmitted by the beet leafhopper, *Circulifer tenellus*. Aster yellows phytoplasma is transmitted by several species of leafhoppers. Both phytoplasmas have wide host ranges. The level of infection in carrot fields is dependent on the population of vectors. Disease incidence may be greater if carrots are planted near areas where weeds and other plants provide a reservoir for the phytoplasmas and their vectors.

MANAGEMENT

There are no effective controls for these diseases.

POWDERY MILDEW (03/24)

Pathogen: *Erysiphe heraclei*

SYMPTOMS AND SIGNS

Older leaves and leaf petioles of plants with powdery mildew are usually covered with a white, powdery growth. Young leaves develop small, circular, white, powdery spots that slowly enlarge to cover the leaflets. A slight chlorosis or yellowing may appear on leaves infected by the fungus.

COMMENTS ON THE DISEASE

The fungus survives on overwintered carrots and related weed hosts. The airborne spores may be carried long distances. Foliar symptoms usually do not appear until leaves are mature, and leaves can survive even with heavy infections. Fungal infection and disease development are favored by high humidity during evening and morning hours, and temperatures between 55° and 90°F. The disease is more severe on drought stressed plants or plants in shaded conditions.

MANAGEMENT

Cultural Control

Use tolerant cultivars if available. Maintain good plant vigor and avoid water/drought stress.

Organically Acceptable Methods

Use cultural control and sprays of sulfur and *Bacillus subtilis* in a certified organic crop.

Treatment Decisions

Chemical controls are not recommended unless infections appear very early in the growing season.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. AZOXYSTROBIN
(Quadris) 9.0–15.5 fl oz 4 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than four foliar applications of strobilurin fungicides per crop.

B. PYRACLOSTROBIN
(Cabrio EG) 8–12 oz 12 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than three applications of strobilurin fungicides per crop.

C. TRIFLOXYSTROBIN
(Flint Extra) 2–2.9 oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: To limit potential for resistance development do not apply more than three sequential applications or a total of four applications of all strobilurins per season. Do not apply more than 11.5 oz/acre per year.

D. PENTHIOPYRAD
(Fontelis) 16–30 fl oz 12 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)
COMMENTS: Begin application prior to disease development and continue on a 7- to 14-day interval. Use higher rate and shorter interval when disease pressure is high.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
E.	PYRACLOSTROBIN/FLUXAPYROXAD			
	(Merivon)	4–5.5 fl oz	12	7
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)/Succinate dehydrogenase inhibitor (7) COMMENTS: For optimal disease control, begin applications of Merivon prior to disease development and continue on a 7- to 14-day interval if conditions are conducive for disease development. Use the higher rate and shorter interval when disease pressure is high. Do not make more than two (2) sequential applications of Merivon before alternating to a labeled non-group 7 or non-group 11 fungicide.			
F.	SULFUR	3–10 lb	24	—
	… OR ….			
	SULFUR DUST#	See label	24	—
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multisite contact (M2) COMMENTS: Apply at the first sign of disease and repeat at 14 days as needed to maintain control.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

Acceptable for use on certified organic crops.

NA Not applicable

ROOT DIEBACK (FORKING AND STUBBING) (03/24)

Pathogens: *Pythium irregulare*, *P. ultimum*

SYMPTOMS AND SIGNS

Root dieback of carrots produces excessively branched or stubbed roots. The fungus kills young taproots less than 2 weeks after seed germination, which reduces root length or stimulates multiple root formation (forking), or both. *Pythium* spp. can also cause damping-off of carrots.

COMMENTS ON THE DISEASE

Only very young tissue is susceptible. The severity of the disease may be dependent on the density of thick-walled *Pythium* oospores (overwintering spores) or sporangia (a structure that encloses spores) in field soils. The pathogens are spread in water and soil. Very wet soil conditions favor the disease. Forking and stubbing can also be caused by hardpans, nematodes, and excessive water, among other factors.

MANAGEMENT

Cultural Control

Avoid overwatering and provide good drainage. Rotating to small grains might reduce soil populations of some *Pythium* spp.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Treatment Decisions

In fields with a history of *Pythium*-related problems, make a preplant treatment.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. MEFENOXAM
(Ridomil Gold SL) 0.5–1 pt 48 7
MODE-OF-ACTION GROUP NAME (NUMBER1): Phenylamide (4)
COMMENTS: Preplant application. Do not apply more than 2.8 pt/acre per crop.

B. CYAZOFAMID
(Ranman 400SC) 6 fl oz 12 14
MODE-OF-ACTION GROUP NAME (NUMBER1): Ubiquinone reductase, Qi site (21)

C. FLUOPICOLIDE
(Presidio) 3–4 fl oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER1): Mitosis and cell division (43)

D. METAM SODIUM*
(Vapam HL) Label rates See label NA
COMMENTS: Apply preplant by sprinkler, drip irrigation, or flood irrigation. Check label for rates and preplant timing. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

E. PHOSPHOROUS ACID
(Fosphite) Label rates 4 0
MODE-OF-ACTION GROUP NAME (NUMBER1): Phosphonate (33)
COMMENTS: Although proven effective in other areas, results from California studies have been mixed.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable

SOUTHERN BLIGHT (03/24)

Pathogen: *Sclerotium rolfsii*

SYMPTOMS AND SIGNS

Southern blight is characterized by a soft watery decay of the taproot at or near the soil line. The disease develops rapidly, resulting in wilting and yellowing of the carrot top. White mats of mycelium develop on the carrot root and in the adjacent soil. Tan to brown round sclerotia (resting structures) about the size of a mustard seed (1.5 mm) develop on mycelial mats. The abundant sclerotia are a good diagnostic feature of southern blight.

COMMENTS ON THE DISEASE

High temperatures (over 85° F) favor the disease. The fungus attacks a wide range of plants and survives for long periods in the soil as sclerotia. Southern blight is typically more prevalent in the Southern San Joaquin Valley in spring planted carrots. It also predisposes carrots to secondary infections such as soft rot.

MANAGEMENT

Cultural Control

Rotation to nonhosts such as corn or small grains for at least two years reduces numbers of sclerotia. Deep plowing to bury sclerotia and infested plant debris helps in reducing sclerotia levels in soil.

Organically Acceptable Methods

Use cultural controls in a certified organic crop.

Treatment Decisions

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 11/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. AZOXYSTROBIN/DIFENOCONAZOLE
(Quadris Top) 14 fl oz 12 7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)/Demethylation inhibitors (3)
COMMENTS: Do not make more than one application before rotating to a fungicide with a different mode of action. Do not make more than four foliar applications of strobilurin fungicides per year.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

Nematodes *(02/24)*

Root-knot nematodes: *Meloidogyne arenaria*, *Meloidogyne hapla*, *Meloidogyne incognita*, *Meloidogyne javanica*
Stubby root nematode: *Paratrichodorus* sp.
Needle nematode: *Longidorus africanus*

DESCRIPTION OF THE PEST

Nematodes are microscopic roundworms that live in diverse habitats. Plant-parasitic nematodes occur in soil and plant tissues. They feed on plants by puncturing cell walls and sucking the cell contents with a needlelike mouthpart called a stylet.

Among nematodes that affect carrots, root-knot nematodes (RKN) are the most important and are widely distributed throughout California. Second-stage juveniles (J2) hatch from eggs, move through soil, and infect plants. They are the only infective stage and seek out and penetrate host plants near their root tips. During their development in carrot roots, third- and fourth-stage juveniles and adult females remain sedentary while inducing root galls and increasing in size. The enlarged posterior end of adult females typically breaks through the root surface and produces an egg mass just outside or beneath the root surface. Several hundred eggs are embedded in a protective gel.

Needle nematode is important in the Imperial Valley, whereas stubby root nematode occurs statewide. Both are migrating ectoparasites (i.e., they feed on but do not penetrate the roots) and lay eggs singly in the soil. They go through four molts, and all juvenile stages probably feed on roots. Both needle and stubby root nematodes must be extracted from the soil to be seen under high magnification.

DAMAGE

Root-knot nematodes can cause substantial damage and are of significant concern in California. Their parasitic activity can damage the growing root, resulting in a forked, galled, or stunted taproot. In addition to the reduced marketability, deformed roots tend to pick up excess soil during harvest, increasing the tare transported to the processing factory. Removal and disposal of excess soil increases cost. Furthermore, root-knot nematodes may cause stand and yield reduction. Heavy stubby root and needle nematode infestations can also stunt root development, resulting in uneven growth and yield reduction.

SYMPTOMS

The symptoms described below suggest a nematode problem, but only root-knot nematode galls are diagnostic. Other symptoms can also result from diseases or abiotic causes.

Injury of the growing tip of the taproot by any species of nematode often causes forking of the taproot, stubbing, fasciculation (bunching) of the roots, and a predisposition to wilting. Typically, this taproot injury occurs within the first few weeks after seed germination. Stubby root nematode may cause thick, short roots. Needle nematode can damage a root's growing point with its long stylet, which causes root elongation to stop, forking, root branching, swelling of root tips, and sometimes root tip necrosis.

The galls (firm, beadlike bumps on the surface) caused by root-knot nematodes, occur on feeder roots. Small, hard-to-see galls are generally associated with Meloidogyne hapla, whereas relatively large, conspicuous galls are usually associated with other Meloidogyne species.

FIELD EVALUATION

If a previous crop was a host for nematodes that can affect carrots, the nematode numbers might be high enough to cause damage to a carrot crop that follows. Identifying the nematode species present is critical to make appropriate management decisions. Send soil samples to a diagnostic laboratory to identify plant-parasitic nematodes.

The following sampling procedure may be used.

1. Divide the field into sampling blocks 5 acres or less, each representing cropping history, crop injury, or soil texture.
2. Take the soil samples within the root zone (3 to 12 inches deep). Take several subsamples randomly from a block, mix them thoroughly, and make a composite sample of about 1 quart for each block.
3. Place the samples in separate plastic bags and include symptomatic plant roots if available.

4. Seal the bags and place a label on the outside with your name, address, location, current and previous crop, and the crop you intend to grow.
5. Keep samples out of the sun, store them cool (but do not freeze), and transport them as soon as possible to a diagnostic laboratory.

Contact your farm advisor for more details about sampling, locating laboratories that process nematode samples, and interpreting sample results.

MANAGEMENT

Cultural Practices

To avoid infesting new fields with plant-parasitic nematodes, good sanitation practices are essential. Clean machinery and equipment thoroughly with water to prevent the movement of infested soil.

Clean fallow (i.e., weed-free) during years when the land is left unplanted is marginally effective in reducing numbers of root-knot nematodes. Crop rotation is often not sufficient for the control of root-knot nematodes because of the co-occurrence of several species and their wide host range. Rotation crops that can reduce numbers of root-knot nematodes include:

- cotton, particularly cultivar Acala NemX HY which is resistant to the race 3 of M. incognita, the only root-knot nematode that can infect cotton, and
- Mi-resistant tomato cultivars (resistant to M. incognita).

Note that such rotations can increase the occurrence of the cotton (melon) aphid or other virus-transmitting pests of concern.

Most crops grown in the Imperial Valley, except cabbage and cauliflower, are susceptible to needle nematode.

Soil solarization can temporarily reduce many soilborne diseases (including those caused by plant-parasitic nematodes) and weeds. It requires a 4- to 6-week treatment during the hottest time of the year. However, the efficacy against plant-parasitic nematodes is, at best, limited to about 12 inches in soil depth. For further information, see *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds* (UC ANR Publication No. 21377).

Resistant Cultivars

Resistance to damage caused by root-knot nematodes (forking and galling), by M. incognita and M. javanica has been developed in new carrot breeding lines, but such cultivars are not yet commercially available.

Date of Planting

The root-knot nematodes M. incognita, M. javanica, and M. arenaria do not penetrate roots at soil temperatures below 59 to 64°F. However, the temperature threshold for root invasion by M. hapla is at about 55 to 57°F. Therefore, schedule planting when soil temperatures are below this level to minimize forking and galling of taproots.

Treatment Decisions

Damage thresholds depend primarily on nematode species, soil type, soil temperature, and cultivar susceptibility. If the environmental conditions are conducive to parasitic nematode activity, pesticide application may be warranted whenever root-knot nematodes or needle nematode are present. Several new non-fumigant nematicides are under development. After damage has occurred there are no control measures available to restore health of the taproot.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 10/23

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

PREPLANT

A. 1,3-DICHLOROPROPENE*§
(Telone II, Telone EC) — Label Rates — 120 — NA
COMMENTS: Follow label recommendations for rates and application procedures. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Telone II is applied by shank injection. Telone EC is applied using drip irrigation systems.

B. METAM SODIUM*§
(Vapam, Sectagon 42) — 50–75 gal — See label — NA
COMMENTS: Contact your farm advisor for advice on the most effective application method for a particular situation. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

C. 1,3-DICHLOROPROPENE*§/CHLOROPICRIN*§
(InLine) — Label rates — See label — NA
COMMENTS: Multipurpose liquid fumigant for the preplant treatment of soil to control plant-parasitic nematodes, symphylans, and certain arthropods and fungal soil-borne pathogens using drip irrigation systems only. Use of a tarp seal is mandatory for all applications of this product. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

D. FLUENSULFONE
(Nimitz CA) — 3.5–7 pints — 12 — NA

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

NA Not applicable.

Weeds

(Section reviewed 04/24)

INTEGRATED WEED MANAGEMENT (04/24)

Carrot is a slow-growing crop that suffers severe yield loss from weed competition. Its thin, feathery leaves do not shade out competing plants and its long growing season creates an opportunity for successive flushes of weeds throughout the growing season. The first four weeks of crop growth are an especially critical period for weed control. At harvest, weeds also present problems when they become entangled in the equipment and in the crop.

An integrated weed management program is essential for carrot production because registered herbicides do not control many problem weeds in carrots, mechanical cultivation and hand hoeing are of limited value because of the high crop plant populations, and carrots are not competitive against weeds. A weed management program that combines good cultural practices with the use of herbicides will control many weed pests of carrots. However, the limited number of herbicides available and the diversity of weeds that grow in carrot fields make it difficult to maintain adequate control throughout the growing season. Generally, more than one herbicide is necessary to effectively control the different weed species. Usually, a preplant or preemergence herbicide is applied followed by one or more postemergence treatments.

The choice of herbicide depends upon the weed species that are expected to occur. Plantback restrictions need to be considered when selecting herbicides because soil residues of some products can limit the growth of sensitive rotational crops. Herbicide labels are the best source of plantback restrictions (i.e., rotational intervals).

Nonchemical options include solarization and flaming. Carrots have a long germination period and flaming must be performed after the weeds have emerged but before the carrots emerge. Carrots are planted with 4 to 8 seed lines on the top of a 40- to 42-inch bed. Since the bed top is only 22 to 24 inches wide, there is no room to cultivate the planted area. Only the shoulders and furrows are cultivated. Additionally, because of the high-density planting, hand weeding is expensive and can seriously damage the crop by removing carrots with the weeds.

MONITORING

Monitor fields and keep records of the weed species that occur in each field during the period of the year when the crop will be grown. Records of weeds occurring at planting time are especially important. Not only are these records valuable in planning which fields to use to grow carrots, they also help track the occurrence of hard-to-control weeds. Avoid fields with high populations of certain weeds such as sowthistle, shepherd's-purse, nightshades, and nutsedge.

WEED MANAGEMENT BEFORE PLANTING

Avoid planting carrots in fields last planted to cereals or in fields with known infestations of perennial weeds: available herbicides do not effectively control perennial weeds. To prevent the buildup of weed seed in the soil, cultivate weeds before they set seed in rotation crops. After harvest of the rotation crop, clean-cultivate the field or plant a green-manure crop to prevent weed infestations. In a typical farm mix of crops, carrots should be planted in the most weed-free fields.

Soil solarization can be used to control most weeds in carrots. It will also control or suppress some other important pests, such as nematodes and soilborne diseases. Soil solarization requires a summer 4- to 6-week fallow season for treatment; it fits in best with a fall-planted crop in the warm Central and Imperial valleys. Solarization is most effective in the top 6 inches of soil. For further information, see *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds* (UC ANR Publication No. 21377).

Metam sodium is used in many carrot fields throughout California, principally for control of soilborne fungal diseases and nematodes. It will also kill emerged weeds, ungerminated weed seeds that have become softened by irrigation, and nutsedge shoots. Application is made about two weeks after a preirrigation before planting the crop. Typical application is through solid-set sprinklers or into a flood irrigation. The minimum time allowed between application and planting the crop is 14 days and can be up to 60 days depending upon environmental conditions, so planning ahead is important.

About two weeks before planting carrots, preirrigate the field to germinate weed seedlings and cultivate to destroy them. Carry out this operation as close to planting time as possible to assure that soil temperature and climatic conditions are similar to those that will occur during the crop germination period, thus maximizing the number of weeds controlled. Cultivate as shallowly as possible to avoid bringing up dormant weed seed from deeper soil layers.

Herbicides that are available to use preplant in carrots include paraquat (Gramoxone), trifluralin (Treflan), glyphosate (Roundup), and pyraflufen ethyl (ET Herbicide/Defoliant). Glyphosate has been particularly helpful in controlling perennial weeds when used as a preplant treatment. Trifluralin will control many annual weeds when used for the entire carrot production season. These products can be used to control emerged weeds just before planting or before the crop

emerges. Be sure the crop has not emerged, however, because emerged plants will be killed if contacted by these herbicides.

WEED MANAGEMENT AFTER PLANTING

Weeds must be controlled in a carrot field throughout the growing season and require some postplant control measures. Close cultivation and hand hoeing must be done carefully to not cause injury to the crop. An herbicide is generally applied before or after the crop emerges, depending on the weed species to be controlled.

Preemergence

Trifluralin can also be used as a preemergence herbicide in carrots if applied by chemigation and done immediately after planting and before weed germination. This method of use will increase the activity on shallowly emerging weeds, such as common purslane, but will limit soil longevity and effectiveness on weeds germinating from deeper in the soil.

Linuron (Lorox) and prometryn (Caparol) are used for preemergence applications; be careful not to exceed label recommendations on rate. These herbicides will control annual broadleaf weeds better than trifluralin, particularly nightshade, mustards, and sowthistle.

S-metolachlor (Dual Magnum) can be used for preemergence application on yellow nutsedge, but care must be taken to select the correct rate. Lower amounts must be used on coarse-textured soils. This herbicide will provide partial control of yellow nutsedge and good control of several broadleaf and grass weeds, including nightshades.

Postemergence

Following crop emergence, clethodim (Select Max), fluazifop-P-butyl (Fusilade), Metribuzin (Tricor DF), and sethoxydim (Poast) can be applied for grass control, and linuron (Lorox) for annual broadleaf weeds and suppression of yellow nutsedge. Grass herbicides are effective in controlling small seedling annual grasses and some perennial grasses. Their effectiveness is reduced when grasses are under moisture stress. Later growth stages of annual grasses are more difficult to control. Of these herbicides, clethodim is the only one that will control annual bluegrass.

Linuron and prometryn can also be used as postemergence herbicides in carrots. Linuron is applied over the top of the crop when the carrots are 3 inches tall, whereas prometryn can be used until the end of the six-true-leaves-stage. Both control emerged weeds and also have soil residual activity against later emerging weeds. Linuron will suppress yellow nutsedge but has little to no effect on purple nutsedge. A repeat application of Linuron is allowed, but it is limited to a total of 1.5 lb a.i./acre per season. Some carryover can occur under certain conditions, creating a plantback problem. Consult the herbicide label before application.

SPECIAL WEED PROBLEMS (04/24)

SOWTHISTLE, LITTLE MALLOW, and NIGHTSHADE

Sowthistle, little mallow, and nightshade are annual weeds that are difficult to control in carrots. The registered herbicides will not control these weeds very well. Avoid growing carrot crops in fields known to be heavily infested with these weeds.

NUTSEDGE

Nutsedge is a serious weed in spring- and summer-planted crops. Yellow and purple nutsedge are perennial weeds that reproduce from underground tubers, which can survive for several years in the soil. Each tuber contains several buds that are capable of producing plants. Only one bud at a time germinates to form a new plant; however, if that bud is destroyed by cultivation or an herbicide, then a new bud sprouts. Control is best achieved by continuous cultivation during a summer fallow period or by rotating to crops where effective herbicide and cultural control methods can be used. For fall-planted carrots, plant after October 15 to avoid serious yield loss in carrots from competition by nutsedges. Glyphosate and metam sodium provide partial control prior to planting. Linuron and S-metolachlor provide partial control of yellow nutsedge during the production season.

COMMON AND SCIENTIFIC NAMES OF WEEDS (04/24)

Common names link to pages with weed descriptions and photos often showing several stages of development.

Common Name	Scientific Name
Barley, Hare	*Hordeum murinum ssp. leporinum*
Barnyardgrass	*Echinochloa crus-galli*
Bermudagrass	*Cynodon dactylon*
Bindweed, Field	*Convolvulus arvensis*
Bluegrass, Annual	*Poa annua*
Canarygrasses	*Phalaris spp.*
Chickweed, Common	*Stellaria media*
Clovers	*Trifolium spp.*
Crabgrasses	*Digitaria spp.*
Cudweeds	*Gnaphalium spp.*
Docks	*Rumex spp.*
Fiddlenecks	*Amsinckia spp.*
Filarees	*Erodium spp.*
Fleabane, Hairy	*Conyza bonariensis*
Foxtails	*Setaria spp.*
Goosefoot, Nettleleaf	*Chenopodium murale*
Groundcherries	*Physalis spp.*
Groundsel, Common	*Senecio vulgaris*
Henbit	*Lamium amplexicaule*
Horseweed	*Conyza canadensis*
Johnsongrass	*Sorghum halepense*
Knotweed, Common	*Polygonum arenastrum*
Lambsquarters, Common	*Chenopodium album*
Lettuce, Prickly	*Lactuca serriola*
Lovegrasses	*Eragrostis spp.*
Mallow, Little (Cheeseweed)	*Malva parviflora*
Morningglory, Annual	*Ipomoea spp.*
Mustards	*Brassica spp.*
Nettles	*Urtica spp.*
Nightshade, Black	*Solanum nigrum*
Nightshade, Hairy	*Solanum sarrachoides*
Nutsedge, Purple	*Cyperus rotundus*
Nutsedge, Yellow	*Cyperus esculentus*
Oat, Wild	*Avena fatua*
Panicum, Fall	*Panicum dichotomiflorum*
Pigweeds	*Amaranthus spp.*
Puncturevine	*Tribulus terrestris*
Purslane, Common	*Portulaca oleracea*
Radish, Wild	*Raphanus raphanistrum*
Rocket, London	*Sisymbrium irio*
Ryegrasses	*Lolium spp.*
Shepherd's-Purse	*Capsella bursa-pastoris*
Sowthistles	*Sonchus spp.*
Sunflowers	*Helianthus spp.*
Thistle, Russian	*Salsola tragus*

SUSCEPTIBILITY OF WEEDS IN CARROT TO HERBICIDE CONTROL (04/24)

Mode of Action[1]	CLE 1	FLU 1	GLY 9	LIN 7	MET 27	MTR 5	PAR 22	PEN 3	PRM 5	SET 1	MEO 15	TRI 3
ANNUAL WEEDS												
Barley, hare	C	C	C	C	C	C	P	C	C	C	–	C
Barnyardgrass	C	C	C	C	C	C	C	C	P	C	C	C
Bluegrass, annual	C	N	C	P	C	P	C	C	C	N	C	C
Canarygrasses	C	C	C	C	C	C	C	C	C	C	–	C
Cereals	C	C	C	P	C	P	C	C	P	C	–	C
Chickweed, common	N	N	C	C	C	C	C	C	C	N	C	C
Clovers	N	N	P	N	N	–	P	N	P	N	–	N
Crabgrasses	C	C	C	C	C	–	C	C	P	C	–	C
Cudweeds	N	N	C	P	C	–	N	N	P	N	–	N
Fiddlenecks	N	N	C	C	C	–	P	C	C	N	–	C
Filarees	N	N	P	C	C	–	P	N	C	N	–	N
Fleabane, hairy	N	N	C	C	C	N	C	N	C	N	–	N
Foxtails	C	C	C	C	C	–	C	C	–	C	–	C
Goosefoot, nettleleaf	N	N	C	C	C	C	C	C	C	N	P	C
Groundcherries	N	N	C	C	C	–	C	N	C	N	–	N
Groundsel, common	N	N	C	P	C	P	C	N	C	N	N	N
Henbit	N	N	C	C	C	–	C	C	C	N	–	C
Horseweed	N	N	C	P	C	C	P	N	C	N	–	N
Knotweed, common	N	N	C	P	C	–	P	C	C	N	N	C
Lambsquarters, common	N	N	C	C	C	C	P	C	C	N	P	C
Lettuce, prickly	N	N	C	C	C	C	P	N	C	N	–	N
Lovegrasses	C	C	C	C	C	–	P	–	P	–	–	C
Mallow, little (cheeseweed)	N	N	P	C	N	C	N	P	C	N	P	N
Morningglory, annual	N	N	C	P	P	–	P	N	C	N	–	N
Mustards	N	N	C	C	C	C	C	P	C	N	N	N
Nettles	N	N	N	C	C	–	P	N	C	N	C	N
Nightshade, black	N	N	C	P	C	–	C	N	C	N	–	N
Nightshade, hairy	N	N	C	C	C	–	C	N	C	N	C	N
Oat, wild	C	C	C	C	C	N	C	P	C	C	–	P
Panicum, fall	–	–	C	C	C	–	N	C	–	–	–	C
Pigweeds	N	N	C	C	P	C	C	P	C	N	C	C
Puncturevine	N	N	C	C	C	–	C	P	P	N	–	P
Purslane, common	N	N	C	C	C	–	C	C	C	N	C	C
Radish, wild	N	N	C	C	C	C	C	N	C	N	–	N
Rocket, London	N	N	C	C	C	C	C	P	C	N	N	N
Ryegrasses	C	C	C	N	C	–	P	C	P	C	–	C
Shepherd's-purse	N	N	C	C	C	C	C	P	C	N	P	N
Sowthistles	N	N	C	P	C	N	P	N	C	N	P	N
Sunflowers	N	N	C	C	C	–	P	N	C	N	–	N
Thistle, Russian	N	N	C	P	C	–	C	P	P	N	–	P
PERENNIAL WEEDS												
Bermudagrass, Established	P	P	C	N	P	N	N	N	N	P	–	N
Bermudagrass, Seedling	C	C	C	N	C	N	P	C	P	C	–	C
Bindweed, field, Established	N	N	P	N	P	N	N	N	N	N	–	P
Bindweed, field, Seedling	N	N	C	N	P	N	P	P	P	N	–	P
Docks, Established	N	N	P	N	C	–	N	N	N	N	–	N
Docks, Seedling	N	N	C	C	C	–	C	C	C	N	–	C
Johnsongrass, Established	C	C	C	N	P	N	N	N	N	C	–	N

Mode of Action[1]	CLE 1	FLU 1	GLY 9	LIN 7	MET 27	MTR 5	PAR 22	PEN 3	PRM 5	SET 1	MEO 15	TRI 3
Johnsongrass, Seedling	C	C	C	N	C	N	C	C	N	C	—	C
Nutsedge, purple	N	N	P	N	P	—	N	N	N	N	—	N
Nutsedge, yellow	N	N	P	P	P	—	N	N	N	N	P	N

Ratings Legend

C control P partial control N no control — no information

Herbicide Legend

CLE clethodim (Select Max)
FLU fluazifop-P-butyl (Fusilade)
GLY glyphosate (Roundup)
LIN linuron (Lorox)
MET metam sodium* (Vapam)
MTR metribuzin (Tricor DF)
PAR paraquat* (Gramoxone)
PEN pendimethalin (Prowl H20)
PRM prometryn (Caparol)
SET sethoydim (Poast)
MEO s-metolachlor (Dual Magnum)
TRI trifluralin (Treflan)

* Permit required from county agricultural commissioner for purchase or use.

[1] Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action.

WEED MANAGEMENT FOR ORGANIC VEGETABLE PRODUCTION (04/24)

Effective weed control in organic vegetable productions depends on an integration of sound cultural practices, careful cultivation, and hand labor. Preventing the production of weed seed in the field before planting will reduce subsequent weeding costs during crop production. Growers that have a zero-tolerance for weeds in all crops have lower weed pressure, and over time, the soil seedbank can be depleted. Certain crops such as fast maturing, high-density plantings of spinach and lettuce can also deplete the soil weed seed bank because these crops are often harvested before many weed seeds can produce seed – provided the field is tilled immediately after harvest.

The first step in developing a weed management program is to survey the planting site and identify the weeds that are there. Become familiar with each weed's growth and reproductive habits to choose the most effective management options. For help in identifying common weeds, see the weed photo pages that are linked to the weed list in the section Common and Scientific Names of Weeds

Vegetables produced in California include both warm-season crops like melons and tomato, as well as cool season crops like carrot, celery and lettuce. The warm-season crops are mostly grown in the central valley and low desert, while the cool-season crops are grown year-round at multiple locations depending on the season, e.g., in the low desert during winter and along the coast during summer. The wide range in vegetable production seasons and locations means that the weed spectrum varies quite widely. Therefore, organic vegetable weed control programs need to be flexible and robust.

It is important to locate plantings in fields with low weed pressure or to use weed management methods that reduce weed pressure before planting. It is also important to keep areas near production fields free from weeds with windblown seed. Some growers use transplants to give the vegetable crop a head start on the weeds. Transplants reduce the number of days to harvest and establish a canopy more quickly. They generally only need one weeding instead of two (as is done with direct-seeded crops) to get through the growth cycle. The goal of organic weed control techniques is to reduce weed pressure and give the crop an advantage over the weeds in order to produce the crop as economically as possible.

WEED MANAGEMENT BEFORE PLANTING

Crop Rotations and Field Sanitation

The previous crop can significantly affect weed pressure in a vegetable crop. A previous crop that has had effective weed control means that fewer weed seed will enter the seedbank infecting later rotational crops. In addition, it is important to keep the areas surrounding the field free of weeds that have aerially dispersed seeds, such as groundsel and sowthistle.

Preplant Germination of Weeds

Preplant germination of weeds (pregermination) involves the use of irrigation or rain to stimulate weed seed germination before planting the crop. The emerged seedlings are then killed using various methods. The time of year, irrigation system, and the interval between irrigation and weed control all affect how well this technique works. Preplant germination can take place before or after beds are formed but must take place before a crop is planted.

Done properly, this method removes up to 50% of the weeds that would have otherwise emerged in the subsequent crop.

1. Preirrigate the field to germinate weeds at least two weeks before planting to assure that the weed spectrum does not change before planting.
    - Changes in the weed spectrum may occur because of changes in the season or weather, such as from winter weeds to summer weeds.
2. Allow weeds to emerge and for the field to dry enough to permit use of shallow tillage.
3. Cultivate as shallowly as possible to avoid bringing up dormant weed seed from deeper soil layers.
4. Shape the beds and apply water to stimulate another flush of weeds.

5. Kill the weeds using shallow cultivation, flaming, or applications of organic herbicides. Cultivate as shallowly as possible to avoid bringing up dormant weed seed from deeper soil layers.
6. Plant the crop immediately on these beds.

Flaming

On seeded crops, flaming can be used to kill a flush of weeds. This technique is particularly effective on crops that have slow seed germination like carrots. The timing of flaming is critical and is done just before the carrot seedlings emerge, but after the weeds have emerged. It is most effective on small broadleaf weeds (i.e., less than 2 true leaves) but not grass weed species because the growing point is below the soil surface.

Deep Plowing

Deep plowing is a tillage technique that buries weed seed or propagules of perennial plants below the depth at which they can germinate or sprout in the case of perennial weeds. The viability of buried weed seed declines over time; longer intervals between deep plowing and subsequent deep plowing (i.e., 3–5 years) are preferred to avoid bringing up large numbers of viable weed seed back to the soil surface.

Cover Crops

The use of cover crops is a key cultural practice in organic production. Cover crops provide a variety of benefits to crop production but can, potentially, both increase or decrease weed pressure in vegetable production systems. Unfortunately, annual weeds frequently become established at the time of the cover crop seeding, and depending upon the weed species, they can grow and set seed unnoticed in cover crops. Often weed plants decompose before the end of the cover crop cycle making their detection difficult. In such cases, the cover crops act as nurse crops to weeds, and allow for substantial contributions to the weed seed bank. Slow-growing winter cover crops (legumes and cereal/legume mixes) can be particularly problematic; many allow significant weed growth and seed set early in the growth cycle of the cover crop. Fast-growing winter cover crops, such as cereals and mustards, provide complete ground cover in the first 30 days of the cover crop cycle and are better able to compete with weeds. Competitive cereal and mustard cover crops varieties include Merced rye (*Secale cereale*), white mustard (*Sinapis alba*), and Indian mustard (*Brassica juncea*). An adequate seeding rate is also an important factor in providing for rapid ground cover. It is important to monitor the cover crops, particularly in the first 40 days following seeding, to make sure that they are not creating a weed problem for subsequent plantings.

Soil Solarization

Solarization can be used in areas with sufficient solar radiation like the central valley and low desert. Typically, the soil is irrigated and then covered with clear plastic for 4 to 6 weeks during the hot summer period. The effectiveness depends mainly on the heat that can be generated under the plastic during a short interval. Soil solarization can reduce amount of weed seed in the soil, as well as provide partial control of root knot nematode and soilborne fungal pathogens. For further information, contact your local farm advisor or see UC ANR Publication #21377, *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*.

WEED MANAGEMENT AFTER PLANTING

Cultivation

Cultivation is one of the most effective postplant weed control practices that can be performed. Organic vegetable crops are typically cultivated at least twice. Traditional inter row cultivation can remove weeds in 80% of the field while leaving a 4-inch-wide uncultivated strip around each seed line.

New intelligent cultivators and laser weeders can cultivate in the seedline near the crop plants removing a high percent of the weeds. These intelligent cultivators will not generally remove all of the weeds but rather remove a large percentage of the weeds thus increasing the efficiency of subsequent hand weeding operations. Alternatives to the intelligent cultivators are devices such as finger weeders and torsion weeders which can remove weeds very close to the crop without damage to the crop. However, the use of these weeders is limited in carrots due to the delicate nature of the crop until later in the crop cycle.

Hand Hoeing

Hand hoeing is essential in organic vegetable crops. Typically, the crop is weeded 30 to 40 days after seeding. At this time the plants are tender, and careful hand weeding is necessary in the seed row to safeguard the crop.

Typically, the initial hand weeding and thinning operation is followed 2 weeks later by a final hand weeding before the crop canopy closes. At present, there are no successful techniques that can substitute for careful hand weeding of direct-seeded crops, but successful employment of the above-mentioned techniques can help make hand weeding operations less time consuming and more efficient.

HERBICIDE TREATMENT TABLE (04/24)

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 04/24

Not all registered pesticides are listed. **The following are listed alphabetically.** When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see Susceptibility of Weeds to Herbicide Control for information on specific weed control. Always read the label of the product being used.

PREPLANT

EPTC — 3.1 lb a.i.
(Eptam 7E) — 3.5 pts — 12 — 100
WSSA MODE-OF-ACTION GROUP NUMBER1: 15
COMMENTS: For suppression of nutsedge and groundsel. Apply 3.5 pints through sprinklers in the initial germination water or mechanically incorporate prior to planting. Can make two additional sprinkler applications during the germination period. Material should be applied during the final stage of the irrigation cycle and no more than 10.5 pints may be applied per crop.

GLYPHOSATE — 1–4.4 lb a.i.
(Roundup PowerMax) — 1–3.3 qt — 4 — NA
WSSA MODE-OF-ACTION GROUP NUMBER1: 9
COMMENTS: A nonselective, foliar herbicide applied to premade beds before planting to kill emerged weeds. Allow 3 days after treatment before planting. Use the lower rate for annual grasses and weeds, the higher rate on perennial weeds. Consult the label for specific recommendations on particular weed species. Do not apply to weeds stressed for moisture. For perennial weeds, allow 7 days after application before cultivating.

METAM SODIUM* — 159.8–319.5 lb a.i.
(Vapam HL) — 37.5–75 gal — 120 (5 days) — NA
COMMENTS: Soil should be free of large clods and irrigated about 2 weeks before application of the metam sodium. For flood applications, meter metam into water continuously throughout the entire irrigation. Sprinkler applications are much quicker; after running the sprinklers 5–10 minutes to moisten the soil surface and to be sure the system is working properly, inject the total amount of metam into the pump in about 20 minutes, then shut off the system. In any chemigation system, it is very important to have controls in place to prevent water flowing backward into the uncontaminated water source. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

PARAQUAT* — 0.67–1.40 lb a.i.
(Gramoxone SL 3.0) — 1.3–2.7 pt — 24 — See label
WSSA MODE-OF-ACTION GROUP NUMBER1: 22
COMMENTS: A nonselective foliar herbicide that kills emerged weeds. Can be used before planting or after planting, but before the crop emerges. Any crop plants exposed to the spray will be killed, even germinating seed in the crook stage. No soil residual activity. Use the lower rate on small broadleaf weeds, the higher rate on larger weeds and grasses. Highly toxic if ingested, inhaled, or exposed through dermal contact; wear protective clothing. More active on warm, sunny days.

TRIFLURALIN — 0.5–1 lb a.i.
(Treflan HFP) — 1-2 pt — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER1: 3
COMMENTS: Controls annual grasses and broadleaf weeds. Incorporate mechanically into the top 2 to 3 inches of the final seedbed. The lower rates are recommended on sandy soil; however, crop tolerance is excellent.

POSTPLANT

Before the crop emerges

LINURON — 0.5–1 lb a.i.
(Lorox DF) — 1–2 lb — 24 — 14
WSSA MODE-OF-ACTION GROUP NUMBER1: 7
COMMENTS: Apply after planting, incorporate with sprinklers. Will control many broadleaf weeds and annual grasses. A postemergence treatment is also allowed but must not exceed a total of 3 lb linuron/acre per year.

PENDIMETHALIN — 0.95 lb a.i.
(Prowl H2O) — 2 pt — 24 — 60
WSSA MODE-OF-ACTION GROUP NUMBER1: 3
COMMENTS: Apply before crop and weeds emerge.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED: 04/24			
PROMETRYN	1–2 lb a.i.		
(Caparol 4L)	2–4 pt	48 (2 days)	30
WSSA MODE-OF-ACTION GROUP NUMBER1: 5			
COMMENTS: Apply after planting, activate with sprinklers. Will control many broadleaf weeds and annual grasses. A postemergence treatment is also allowed but must not exceed a total of 4 pt prometryn/acre per crop cycle.			
S-METOLACHLOR	0.64–1.927 lb a.i.		
(Dual Magnum)	0.67–1.33 pt	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER1: 15			
COMMENTS: For control of yellow nutsedge. Make a single broadcast application preplant incorporated, preplant surface applied, or preemergence to clean-tilled soil. Use lower rates on coarse-textured soils and higher rates on heavier soils. Read the label carefully for further details on the use of this material.			
TRIFLURALIN	0.5–1 lb a.i.		
(Trifluralin HF)	1–2 pt	12	NA
WSSA MODE-OF-ACTION GROUP NUMBER1: 3			
COMMENTS: Apply through irrigation after sowing to prevent weed germination. See label for plantback restrictions.			
After the crop emerges			
CLETHODIM	0.091-0.121 lb a.i.		
(Select Max)	12–16 fl oz	24	30
WSSA MODE-OF-ACTION GROUP NUMBER1: 1			
COMMENTS: Controls annual bluegrass in the 2- to 3-leaf stage as well as other annual and some perennial grasses. Do not apply through any type of irrigation system. Always apply with a crop oil concentrate. Use higher rate on perennial grasses.			
FLUAZIFOP-P-BUTYL	0.25–0.37 lb a.i.		
(Fusilade DX)	16–24 fl oz	12	45
WSSA MODE-OF-ACTION GROUP NUMBER1: 1			
COMMENTS: A selective foliar herbicide for control of grasses. A surfactant (crop oil concentrate or nonionic surfactant) is recommended. Safe to the crop. Not effective on drought-stressed grasses or on certain species (e.g., annual bluegrass, sprangletop). Do not apply more than 48 fl oz/acre per season.			
LINURON	0.5–1 lb a.i.		
(Lorox DF)	1.5–3 lb	24	14
WSSA MODE-OF-ACTION GROUP NUMBER1: 7			
COMMENTS: May be applied twice, first when the crop is 3 inches tall. Good control of emerged broadleaf weeds, small grasses, and suppression of yellow nutsedge. Total per season must not exceed 3 lb/acre (or 1.5 lb a.i./acre).			
METRIBUZIN	0.25 lb a.i.		
(Tricor DF)	0.33 lb	12	60
WSSA MODE-OF-ACTION GROUP NUMBER1: 5			
PROMETRYN	1–2 lb a.i.		
(Caparol 4L)	2–4 pt	48 (2 days)	30
WSSA MODE-OF-ACTION GROUP NUMBER1: 5			
COMMENTS: Apply after planting, incorporate with sprinklers. Will control many broadleaf weeds and annual grasses. Must not exceed a total of 4 pt prometryn/acre per crop cycle.			
SETHOXYDIM	0.09–0.46 lb a.i.		
(Poast)	0.5–2.5 pt	12	30
WSSA MODE-OF-ACTION GROUP NUMBER1: 1			
COMMENTS: A selective foliar herbicide for control of grasses. A surfactant (crop oil concentrate or nonionic surfactant) is recommended. Safe to the crop. Not effective on drought-stressed grasses or certain species (e.g., annual bluegrass, sprangletop).			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED: 04/24

[1] Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action.

* Permit required from county agricultural commissioner for purchase or use.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

Precautions for Using Pesticides

Pesticides are poisonous and must be used with caution. **READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER.** Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest's name.

Legal responsibility

The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation

Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage

Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. **DO NOT** store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container disposal

Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of nonpest animals and plants

Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting treated fields

For some materials, **restricted entry intervals** are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest intervals

Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit requirements

Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Maximum residue levels

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of importing country at mrldatabase.com.

Processed crops

Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop injury

Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal safety

Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. **NEVER** eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care **IN ADVANCE** as required by regulation.

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