

UC IPM Pest Management Guidelines: SUGARBEET

January 2013

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

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An illustrated version of this guideline is available online at <http://www.ipm.ucdavis.edu/PMG/selectnewpest.sugarbeet.html>

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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM Web site 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 check the label and 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.

General Information

RELATIVE TOXICITIES OF PESTICIDES USED IN SUGARBEET TO NATURAL ENEMIES AND HONEY BEES (1/10)

Common name (trade name)	Mode of action ¹	Selectivity ² (affected groups)	Predatory mites ³	General predators ⁴	Parasites ⁴	Honey bees ⁵	Duration of impact to natural enemies ⁶
<i>Bacillus thuringiensis</i> ssp. <i>aizawai</i>	11	narrow (caterpillars)	L	L	L	IV	short
<i>Bacillus thuringiensis</i> ssp. <i>kurstaki</i>	11	narrow (caterpillars)	L	L	L	IV	short
carbaryl (Sevin) bait	1A	narrow (cutworms, armyworms, grasshoppers, etc.)	L	L	L	IV	short
carbaryl (Sevin) 80	1A	broad (insects, mites)	M/H	H	H	I ⁸	long
carbaryl (Sevin) XLR Plus	1A	broad (insects, mites)	L	H	L	I ⁹	long
chlorpyrifos (Lorsban)	1B	broad (insects, mites)	M	H	H	I ¹⁰	moderate
esfenvalerate (Asana)	3	broad (insects, mites)	H	M	H	I ¹¹	moderate
imidacloprid (Admire)	4A	narrow (sucking insects, beet armyworm, cutworms)	—	L	—	I ¹²	—
insecticidal soap (M-Pede)	—	broad (exposed insects, mites)	M	M	M	IV	short
methomyl (Lannate)	1A	broad (insects, mites)	H	H	H	III	moderate
methoxyfenozide (Intrepid)	18A	narrow (caterpillars)	L	L	L	IV	short
naled (Dibrom)	1B	broad (insects, mites)	H	H	H	I ¹³	—
oxydemeton-methyl (MSR Spray Concentrate)	1B	narrow (sucking insects, mites)	H	H	H	III	moderate
petroleum oils	—	broad (exposed insects, mites)	L ¹⁴	L	L	III	short
phorate (Thimet) granules	1B	—	—	—	—	IV	short
spinosad (Entrust, Success)	5	narrow (caterpillars, whiteflies, aphids, leafminers)	L/H	M ¹⁵	L/M	III	short to moderate
sulfur	—	narrow (mites)	L/H	M/L	H	IV	short

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

- 1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.
- 2 Selectivity: *broad* means it affects most groups of insects and mites; *narrow* means it affects only a few specific groups.
- 3 Generally, toxicities are to western predatory mite, *Galendromus occidentalis*. Where differences have been measured in toxicity of the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain/native strain.
- 4 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate.
- 5 Ratings are as follows: I-Do not apply to blooming plants; II-Apply only during late evening; III-Apply only during late evening, night, or early morning; and IV-Apply at any time with reasonable safety to bees. For more information, see *How to Reduce Bee Poisoning From Pesticides*, Pacific Northwest Extension Publication PNW591.
- 6 Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.
- 7 Not hazardous to bees when applied at least 4 weeks before bloom.
- 8 If rate is 1 lb a.i. or less, rating is II.
- 9 If rate is 1.5 lb a.i. or less and dilution not greater than 1:19, rating is II.
- 10 If rate is 0.05 lb a.i./acre or less, rating is III.
- 11 If rate is 0.025 lb a.i./acre, rating is II.
- 12 If rate is 0.1 lb a.i./acre, rating is II.
- 13 If rate is 0.5 lb a.i./acre or less, rating is III.
- 14 Rating depends on rate used.
- 15 Toxic against some natural enemies (predatory thrips, syrphid fly larvae) when sprayed and shortly after (8-24 hours).

Acknowledgements: 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 and Mites

(Section reviewed 11/05)

APHIDS: GENERAL CONSIDERATIONS (1/10)

APHID SPECIES

In addition to aphids described in this guideline, there are several other species that may be found on beets throughout the year. Many occur in extremely low numbers and cause no damage. If, however, you encounter large numbers of an aphid or aphids that do not fit any of the following descriptions, please contact your farm advisor or county agricultural commissioner immediately. New species are constantly appearing and your assistance in finding these is greatly appreciated.

CHARACTERISTICS USED IN IDENTIFICATION

The *antennae* are appendages arising one each from the side of the head and function as sense organs. *Frontal tubercles* are small protuberances arising from the front of the head between and at the base of the antennae. They may be absent in some species. When present, they are usually rather prominent and may be convergent, pointing inward toward each other, or divergent, pointing outward away from each other. The *cornicles* are tubular structures that arise one each on the side of the body near the rear end. The *cauda* is a process resembling a tail and arises from the tip of the abdomen. Depending on species, it may be elongated, knobbed, triangular, or other shapes.

BIOLOGICAL CONTROL

All aphids associated with sugarbeets are attacked by the same group of natural enemies. These include lady beetles such as the convergent lady beetle, *Hippodamia convergens*; the ninespotted lady beetle (normally not spotted in California), *Coccinella novemnotata*; and the sevenspotted lady beetle, *C. septempunctata*. Other important natural enemies are syrphid fly larvae, lacewing larvae, and parasitic wasps that cause aphids to develop into mummies (i.e., their bodies become dried and bloated and turn black or tan in color), and a fungus that attacks aphids but not plants, causing them to appear flattened or plastered to the leaf.

MONITORING

Aphid flights are most common during periods of moderate temperatures (60° to 80°F, 15° to 27°C). Monitor fields in the winter and spring from December through April. If aphids become numerous, increase frequency of sampling. Aphids are often concentrated in hot spots or near the field margin. Note the presence of any hot spots but avoid sampling only those areas. Also be sure to look for evidence of biological control; i.e., the presence of predators, parasites (aphid mummies), and disease.

BEAN APHID (1/10)

Scientific Name: *Aphis fabae*

DESCRIPTION OF THE PEST

Bean aphid is present in the Imperial Valley, but it is not a common pest of sugarbeets there.

Bean aphid is a dark olive green to black aphid. It is most easily confused with the cowpea aphid. Bean aphid has a dull, matte appearance while cowpea aphid is shiny. The cauda of the bean aphid has more hairs than that of the cowpea aphid and thus appears bushy. Except for the presence of wings, the winged form of the bean aphid is similar in appearance to the wingless one.

DAMAGE

Injury from bean aphid occurs from virus transmission and from direct feeding on sugarbeet leaves. Bean aphids transmit *Beet yellows virus*, *Beet western yellows virus*, and *Beet mosaic virus*. Although bean aphids do not vector viruses as efficiently as green peach aphid, generally bean aphid occurs at higher densities, which tends to negate the differences in virus transmission efficiency.

Infestations of bean aphid generally begin on young leaves in the center of the crown. As the number of individuals increases, older leaves are colonized. The aphid is found mainly on the underside of leaves and only rarely on upper surfaces. Infested leaves curl under and inward and become severely distorted. The leaf margin and eventually the entire leaf become necrotic. Heavy populations may kill foliage, even in large mature plants. Bean aphid produces large amounts of honeydew, and infested leaves are usually covered with sooty mold. If the aphids are killed, either by insecticides or natural enemies, leaves resprout from the crown and new foliage begins growing.

MANAGEMENT

The principal way of reducing virus transmission by the bean aphid is adherence to the beet-free restrictions and planting dates established by grower and processor agreement. These planting date restrictions are established to avoid planting during major aphid flights and to prevent the virus source (i.e., infected sugarbeet plants), from bridging the time between old and new plantings. Planting date restrictions and beet-free periods vary considerably from location to location; contact your farm advisor, processor, or the California Beet Growers Association for the latest restrictions in your area. Strict adherence to these restrictions is absolutely necessary in order to reduce the amount of virus.

A second, and equally important, factor in reducing virus spread is good field sanitation. Infected keeper beets that produce new vegetative growth after harvest act as sources of virus inoculum for new plantings. Following harvest, thoroughly disc fields and chop remaining beets into small pieces. Watch fields closely and redisc if new growth appears. Take special care where keeper beets resprout in other crops, such as cereals or alfalfa. In such cases, herbicides may be required to control the new growth in order to reduce virus inoculum. These measures help control the incidence and spread of viruses transmitted by bean aphid but do little in controlling the aphid itself.

Biological Control

Bean aphids are attacked by a variety of common aphid predators and parasites. Lady beetles, green lacewing larvae, and syrphid fly larvae are frequently found associated with bean aphid colonies. Note the presence of these predators and their impact on aphid populations during routine monitoring. If these predators are present and aphid numbers are declining, delay chemical intervention.

Bean aphid is attacked by a very prolific parasitic wasp, *Lysiphlebus testaceipes*. Parasitized aphids become bloated and their bodies turn tan in color. This parasite can control extensive populations of bean aphid in a few days, and if parasite activity is evident, chemical treatments should be delayed or canceled. Bean aphid is also attacked by a fungus disease that leaves the aphid body flattened so it appears to be glued to the leaf. Like the parasite, this fungus disease may control the aphid population within a matter of days. This disease is most prevalent in spring during rainy periods. In most cases, a combination of these biological control agents work in concert to reduce aphid numbers.

Monitoring and Treatment Decisions

Infestations of black bean aphid and infection with beet yellow virus are most damaging to the plant near the time of seedling emergence. For April to May plantings, the first 6 to 8 weeks after emergence is the most critical time to protect sugarbeet from black bean aphid and beet yellow virus. Monitor sugarbeet plants and evaluate the aphid population and the extent of direct feeding damage to plants. Determine damage levels caused by direct feeding from the following table:

Damage Level	Aphid Infestations and Associated Injury
0	No visual injury; no aphids, or if aphids present, confined to isolated winged individuals.
1	No visual injury; aphids present in small colonies in center leaves of plants; up to 20% of center leaf surface covered with aphids but no plant stunting.
2	Margins of leaf curled inward toward midrib; aphids present on most leaves, covering between 20-40% of leaf surface; obvious honeydew and plant stunting.
3	Leaves severely curled but petioles upright; aphids present on all leaves, covering 40-60% of leaf surface; honeydew prevalent and plant severely stunted.
4	Leaves severely curled; aphids covering 60-80% of leaf surface.
5	Plant collapsed; aphids covering 80-100% of leaf surface.

The following treatment guidelines are provisional, but helpful in making treatment decisions. These guidelines are based on: (1) plant age (from seedling emergence) at the time of infestation; (2) severity of infestation and associated injury; and (3) the length of time the plants remain infested. Based on the above damaged levels and age of the plant, treatment guidelines are as follows:

Plant age in weeks from emergence	Treat if 3-5% of plants reach damage level ¹
Up to 4	1
4-8	2
8-12	2
12-16	2-3
16-20	2-3
20-24	3
24 and up	3-4 ²

¹ If natural enemies are active and aphid numbers are declining, delay treatment for 3-5 days. If after this period, aphid numbers continue to decline, and the next damage level is not reached, treatment may not be necessary.

² Plants within 2-3 weeks of harvest can tolerate up to damage level 4.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. PHORATE* (Thimet) 20G	4.5 oz/1000 row ft or 4.9–7.5 lb	72	30—at planting 30—postemergence
MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not place phorate granules in direct contact with seed. Do not feed tops or silage to dairy cattle. Place granules to the side of seed or in a band over the row. Do not apply by air or make more than one applications/season.			
B. METHOMYL* (Lannate) SP	0.25–1 lb	48	see comments
(Lannate) LV	0.75–3 pt	48	see comments
MODE OF ACTION GROUP NUMBER ¹ : 1A COMMENTS: Preharvest interval is 21 days for roots, 30 days for tops.			
C. OXYDEMETON-METHYL* (MSR Spray Concentrate)	1.5–3 pt	72	30—tops and roots
MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: No more than 2 applications/year.			
D. CHLORPYRIFOS* (Lorsban Advanced)	0.75 pt	24	30—tops and roots
MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Apply as a broadcast foliar spray. Do not apply more than 6 pt or make more than 3 applications/season. Avoid drift and tailwater runoff into surface waters.			

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irc-online.org.

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

GREEN PEACH APHID (1/10)

Scientific Name: *Myzus persicae*

DESCRIPTION OF THE PEST

Green peach aphid is among the most common aphid species found on sugarbeet. The aphid may be present at any time throughout the year but is most common in the Imperial Valley from December through April. Generally its color is palegreen, although at times individuals may be present that are pinkish. During cool weather, individuals are usually more deeply pigmented and may be confused with the potato aphid (see section on Other Aphids), but the two can be distinguished on close examination. The frontal tubercles at the base of the antennae in the green peach aphid are very prominent and convergent. The potato aphid is much larger than the green peach aphid with longer legs, antennae, and cornicles. While they do have prominent frontal tubercles, they are divergent, not convergent as in the green peach aphid. Winged forms of the green peach aphid have a distinct dark patch on the top of the abdomen; wingless forms lack this dark patch.

DAMAGE

Injury caused by the green peach aphid is mainly through its ability to transmit a number of destructive beet viruses. It is the principal vector of *Beet yellows virus*, *Beet western yellows virus*, and *Beet mosaic virus*. It does not transmit *Curly top virus*, *Lettuce chlorosis virus*, or *Rhizomania (Beet necrotic yellow vein virus)*.

Green peach aphid can also damage the plant by sucking plant sap. When damaging levels occur, large numbers of aphids can be found on the underside of leaves. Extensive feeding causes plants to turn yellow and the leaves to curl downward and inward from the edges. Aphid damage is most prominent on newer, younger leaves in the center of the plant.

MANAGEMENT

The principal way of reducing virus transmission by the green peach aphid is adherence to the beet-free restrictions and planting dates established by grower and processor agreement. These planting date restrictions are established to avoid planting during major aphid flights and to prevent the virus source (i.e., infected sugarbeet plants), from bridging the time between old and new plantings. Planting date restrictions and beet-free periods vary considerably from location to location; contact your farm advisor, processor, or the California Beet Growers Association for the latest restrictions in your area. Strict adherence to these restrictions is absolutely necessary in order to reduce the amount of virus.

A second, and equally important factor in reducing virus spread, is good field sanitation. Infected keeper beets that produce new vegetative growth after harvest act as sources of virus inoculum for new plantings. Following harvest, thoroughly disc fields and chop remaining beets into small pieces. Watch fields closely and redisc if new growth appears. Take special care where keeper beets resprout in other crops, such as cereals or alfalfa. In such cases, herbicides may be required to control the new growth in order to reduce virus inoculum. These measures help control the incidence and spread of viruses transmitted by green peach aphid but do little in controlling the aphid itself.

Biological Control

Green peach aphid is attacked by a number of common predators and parasites and is susceptible to the fungus disease that commonly attacks aphids. Aphid sampling should always include an evaluation of the presence and activity of natural enemies.

Monitoring and Treatment Decisions

Treatment of aphids to prevent or reduce the incidence of beet viruses is of little value and is not recommended. Treatment thresholds for green peach aphid, as a pest in its own right, are not well established. Heavy populations can do extensive damage, particularly on seedlings or young plants. Consider treating plants less than 12 weeks of age if aphids are present in numbers sufficient to cause stunting. Older plants can tolerate considerably more aphids and if heavy infestation occurs 3 to 4 weeks before harvest, harvest the field instead of spraying.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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NOTE: The green peach aphid has developed high levels of resistance to many of the insecticides used for its control. These insecticides may provide only partial control.

The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. PHORATE* (Thimet) 20G	4.5 oz/1000 row ft or 4.9–7.4 lb	72	30—at planting 30—postemergence
MODE OF ACTION GROUP NUMBER ¹ : 1B			
COMMENTS: Do not place phorate granules in direct contact with seed. Do not feed tops or silage to dairy cattle. Place granules to the side of seed or in a band over the row. Do not apply by air or make more than one applications per season.			
B. OXYDEMETON-METHYL* (MSR Spray Concentrate)	1.5–3 pt	72	30—tops and roots
MODE OF ACTION GROUP NUMBER ¹ : 1B			
COMMENTS: No more than 2 applications per year.			

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

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OTHER APHIDS (1/10)

Scientific Names: Cowpea aphid *Aphis craccivora*
 Cotton (melon) aphid: *Aphis gossypii*
 Potato aphid: *Macrosiphum euphorbiae*
 Bird cherry-oat aphid: *Rhopalosiphum padi*

Occasionally aphids, particularly winged forms, of the above species may be found in sugarbeet. With the exception of potato aphid, they rarely, if ever, colonize sugarbeet. Control is rarely required when these species are present. Some of these species are known to vector *Beet yellows virus* and *Beet mosaic virus*, but their exact role is not thoroughly known.

SUGARBEET ROOT APHID (1/10)

Scientific Name: *Pemphigus populivenae* (betae)

DESCRIPTION OF THE PEST

Sugarbeet root aphid, as the name implies, is restricted to the roots; generally, the aphid is associated with fibrous roots rather than the main storage root. Winged aphids may occasionally be seen in woolly wax masses in the crown as they crawl up from the roots to fly to new hosts. Wingless forms found on roots are yellowish in color and secrete a dull, white waxy substance, giving the root a mealy appearance.

This aphid is more commonly found in the Central Valley; it is not common in Imperial Valley.

DAMAGE

Severely infested plants become chlorotic and wilt easily; under conditions of prolonged moisture stress, the storage root becomes flaccid and rubbery. Infestations in the field often appear as circular or elliptical patches in which the foliage on plants is wilted or, in extreme cases, collapsed and dying.

MANAGEMENT

Thoroughly work infested fields immediately following harvest and destroy all ground keepers (beets left in the field following harvest). Destroy weed hosts, particularly lambsquarters and redroot pigweed, giving special attention to field margins, which may not come under the usual postharvest tillage program. Do not replant fields to a host crop (sugarbeets, table beets, spinach, chard) for a minimum of 3 years, and control potential weed hosts in all succeeding crops. Thoroughly clean all equipment and implements before moving from an infested to a noninfested field. Never use tailwater from an infested field to irrigate a field planted to a susceptible host because the aphid is readily transported in irrigation water. Finally, avoid water stress and keep the interval between irrigation cut-off and harvest to a minimum, as yield and quality losses are greatest in water-stressed sugarbeets.

Biological Control

Sugarbeet root aphid is attacked by the larvae of a predatory fly and is susceptible to a fungus disease. It is doubtful that either are capable of controlling aphid populations at this time, but the importance of these controls may increase in the future.

Monitoring and Treatment Decisions

No economic thresholds have been established for sugarbeet root aphid. However, studies in California show that even light to moderate infestations (less than 10%) can cause serious yield reductions. If sugarbeet root aphid is found, implement the cultural and sanitary practices outlined above. No chemicals are currently registered for use on sugarbeet root aphid in California.

ARMYWORMS (1/10)

Scientific Names: Beet armyworm: *Spodoptera exigua*
Western yellowstriped armyworm: *Spodoptera praefica*

DESCRIPTION OF THE PESTS

Adult beet armyworms are small, mottled gray- or dusky-winged moths. Females deposit pale greenish or pinkish striated eggs on leaves in small or large masses covered with white cottony material. Eggs hatch in a few days and tiny caterpillars begin feeding on the plant. When caterpillars are full grown in about 2 to 3 weeks, they are about 1.25 inches long. The color down the middle of the back may be olive green to almost black with a yellow stripe on each side of the body. There is a dark spot on each side of the thorax just above the middle leg. Beet armyworms may become abundant and cause severe injury in summer and fall.

Western yellowstriped armyworm may be abundant in fields in the Central Valley any time from June to early September. The caterpillar is usually black, with two prominent stripes and many narrow bright ones on each side. At maturity it is approximately 1.5 to 2 inches long. Eggs are laid in clusters and covered with a gray, cottony material.

DAMAGE

Armyworms skeletonize leaves, leaving the veins largely intact. In severe infestations, as food becomes scarce they will consume the veins, petioles, and will even feed on the exposed portions of the beet root. If infestations occur very early in the crop, particularly during cotyledon stages of fall-planted beets, caterpillars can consume the entire plant and cause reductions in stand. During mid-season, severe defoliation can cause reductions in root size. During the latter parts of the season, regrowth that occurs to compensate for skeletonized leaves can reduce percentage sucrose in the harvested root.

MANAGEMENT

Because of their ability to reach high numbers and cause severe defoliation, armyworms need to be monitored closely, particularly during the mid- and late summer. Control is attained through a combination of beneficial insects and a viral disease coupled with periodic insecticide applications.

Biological Control

Armyworm larvae are attacked by a parasitic wasp *Hyposoter exiguae*. Parasitized larvae can be identified by removing the head and rolling the internal contents of the worm out and looking for pale green parasite larva. Several other parasites also attack armyworm.

Armyworm eggs and small larvae are also preyed upon by numerous predators such as lacewings, minute pirate bugs, damsel bugs, and big-eyed bugs. Assassin bugs will feed on a range of sizes of larvae.

Virus and bacterial diseases of armyworms, the most common of which is nuclear polyhedrosis virus, provide some level of natural control. Diseased caterpillars first appear yellowish and limp, and after death hang from the plant as shapeless, dark tubes from which the disintegrated body contents ooze. Virus spreads as healthy caterpillars feed on leaf tissue containing virions on their surface. The level of virus infection in caterpillars is lowest early in the season and increases throughout the summer. The greatest impacts of virus are seen when caterpillar populations are allowed to be high, as increased pest density facilitates spread of the disease. In such cases caterpillar populations are often observed to crash quickly and remain that way for the remainder of the season.

Organically Acceptable Methods

Biological control and sprays of Bt and the Entrust formulation of spinosad are acceptable for use on organically certified sugarbeets.

Monitoring and Treatment Decisions

Monitor for armyworm larvae by taking sweep samples in a couple of locations of each field weekly. Beet armyworm adults can be monitored using pheromone traps. Pheromone traps are used primarily to determine

when each of the three to four flights occurs and for timing applications of insecticides, such as *Bacillus thuringiensis*, that target young larvae.

Economic thresholds based on worm populations have not been established for beet armyworm. Sugarbeets can compensate for considerable amounts of defoliation in the middle and latter parts of the season without reductions of yield or sucrose percentage. Treat only if natural (biological) pest suppression fails to bring the populations under control. Once the crop has neared irrigation shutoff, even severe defoliation will not effect yield, but may cause reductions in percentage sucrose. Treat only if there is sufficient defoliation to cause the plant to try to regrow foliage instead of storing energy in the taproot during the period from a few weeks before to just after cutting the water.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. METHOXYFENOZIDE (Intrepid) 2F MODE OF ACTION GROUP NUMBER ¹ : 18A	4–10 fl oz	4	1
B. SPINOSAD (Entrust)# (Success) MODE OF ACTION GROUP NUMBER ¹ : 5 COMMENTS: Do not apply more than 0.33 lb spinosad / acre / crop.	1.5–3 oz 4.5–6 fl oz	4 4	3 3
C. METHOMYL* (Lannate) LV (Lannate) SP MODE OF ACTION GROUP NUMBER ¹ : 1A COMMENTS: Preharvest interval is 21 days for roots, 30 days for tops.	0.75–3 pt 0.25–1 lb	48 48	see comments see comments
D. CHLORPYRIFOS* (Lorsban Advanced) MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Avoid drift and tailwater runoff into surface waters or choose alternative materials.	2 pt	24	30–tops and roots
E. BACILLUS THURINGIENSIS ssp. AIZAWAI# (various products) MODE OF ACTION GROUP NUMBER ¹ : 11 COMMENTS: Addition of feeding stimulants improves effectiveness of this material. Worms are feeding within the leaf canopy so spray deposition must occur in this area. Thorough coverage is essential; ground application may provide better control than aerial application. Only effective on small (1st and 2nd instar) larvae.	Label rates	4	0

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

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

BEET LEAFHOPPER (1/10)

Scientific Name: *Circulifer tenellus*

DESCRIPTION OF THE PEST

The beet leafhopper is approximately 0.125 inches long, wedge-shaped, and pale green to gray or brown in color. It may have dark markings on the upper surface of the body. It can be distinguished from *Empoasca* leafhoppers by its darker markings; *Empoasca* leafhoppers are a uniform green color. Beet leafhopper overwinters on rangeland weeds and migrates to sugarbeet and other crops in spring as its overwintering hosts die.

DAMAGE

Direct feeding by beet leafhopper causes relatively minor damage. Its pest status derives from its transmission of *Beet curly top virus* and other related viruses. *Beet curly top virus* is an extremely destructive disease of sugarbeet as well as other crops (e.g., tomatoes). The leaves of plants infected with this virus are dwarfed, crinkled, and rolled upward and inward. Veins are roughened and often swollen. Roots become distorted, often with a proliferation of hair roots (not to be confused with Rhizomania). Phloem tissue often becomes necrotic and appears as dark rings in cross sections or dark streaks in longitudinal sections of the root.

MANAGEMENT

Weed control in areas surrounding the field can help reduce sources of *Beet curly top virus* inoculum.

Cultural Control

Removal of weeds and volunteer beets surrounding sugarbeet fields can play an important role in reducing sources of inoculum available to migrating leafhoppers.

Monitoring and Treatment Decisions

Foliar insecticides have not proven to be generally effective in controlling beet leafhopper or reducing the incidence of *Beet curly top virus* when applied directly to the sugarbeet crop. Occasionally systemic insecticides have proven valuable in reducing the incidence of this virus. The effectiveness of these materials depends on the climatic factors affecting weed hosts of the leafhopper and the virus, timing of planting and application of materials relative to leafhopper migration, and proximity of fields to leafhopper and virus overwintering sites.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. PHORATE* (Thimet) 20G	4.5 oz/1000 row ft or 4.9–7.4 lb	72	30—at planting 30—postemergence
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MODE OF ACTION GROUP NUMBER¹: 1B

COMMENTS: Has been successful in reducing damage from *Beet curly top virus* in research settings, but efficacy under field conditions cannot be guaranteed. Do not place phorate granules in direct contact with seed. Do not feed tops or silage to dairy cattle. Place granules to the side of seed or in a band over the row. Do not apply by air or make more than one applications/season.

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- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.
 - * Permit required from county agricultural commissioner for purchase or use.

CUTWORMS (1/10)

Scientific Names: Pale western cutworm: *Agrotis orthogonia*
 Black cutworm: *Agrotis ipsilon*
 Granulate cutworm: *Feltia* (= *Agrotis*) *subterranea*
 Variegated cutworm: *Peridroma saucia*
 Army cutworm: *Euxoa auxiliaris*

DESCRIPTION OF THE PESTS

The pale western cutworm is a large (1.5 to 2 inches when fully grown) grayish caterpillar with no conspicuous markings except for a dark inverted V on the head. They live in the soil at the base of plants and are thus not seen until damage is apparent.

The black cutworm larva is gray to dark brown above and has a greasy appearance. Faint light stripes run lengthwise down the body. It also lives in soil, and like the pale western cutworm is usually not seen until damage is found.

The granulate cutworm is about an inch long when mature, dark gray in color, and the surface of its body is covered with black granules. It lives in the soil and cuts plants off below ground.

The variegated cutworm is a dark gray caterpillar with a light stripe on the side and small yellow to orange spots on top of the abdominal segments. Fully-grown larvae may be 1.5 to 2 inches long. Variegated cutworm is a climbing species, and while mostly nocturnal, may frequently be found feeding during the day.

The army cutworm is pale greenish gray to brown with the back pale-striped and finely splotched with white and brown.

Several other species of cutworms may be found in sugarbeets and their habits and control are similar to the species listed above.

DAMAGE

The subterranean species (pale western, black, and granulate cutworms), feed largely underground, cutting plants off below the soil line. Frequently, many plants in a row will be cut off during the night; often this is the first indication of a problem. The black cutworm is especially active and has the habit of cutting off many plants while feeding. The granulate cutworm is primarily a pest of sugarbeet grown near alfalfa in the Imperial Valley. On occasion it migrates out of the alfalfa fields into sugarbeet, where it can consume young plants or clip them off below the ground as they feed. Granulate cutworm moths have been found to lay eggs on sugarbeet, and hatching larvae kill plants by eating them to the ground or by clipping them off at ground level, thus reducing plant stands.

The variegated and army cutworms are aboveground feeders and cut the plants off at or above the soil line. They also climb onto older plants and feed mostly on young foliage in the center of the crown. They generally cause only minor damage at this point.

MANAGEMENT

Biological Control

Cutworms are attacked by a number of predators, parasites, and diseases. Many of these natural control agents are not effective on pale western and black cutworms because of their subterranean nature. It is not known if any of these natural enemies can control cutworm populations, but their presence should be noted.

Cultural Control

Cutworms often build up in rotation crops preceding sugarbeet, such as alfalfa and cereals. If surveys indicate the presence of substantial numbers of cutworms in these crops, sugarbeet should not be planted. Spring plowing and disking are also useful in reducing cutworm numbers. Keep fields weed-free, especially eliminating grassy weeds that serve as alternate hosts for cutworms. Cutworms may also build up in high numbers if grassy weeds are prevalent in the crop preceding sugarbeets.

Monitoring and Treatment Decisions

Monitor for cutworms during stand establishment by looking for plants lying on their sides that have been chewed at the soil surface or that are completely missing. If plants are missing completely, gently dig in the area where a seedling would be expected to try to find the intact root system as evidence of cutworm damage.

No economic thresholds have been established for cutworms, and the decision to treat depends on the severity of injury. Organophosphate (chlorpyrifos) and carbamate (methomyl, carbaryl) insecticides do not control the granulate cutworm; check with your farm advisor concerning the availability of materials to control this pest.

Common name (trade name)	Amount per acre	R.E.I.# (hours)	P.H.I.# (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. METHOXYFENOZIDE (Intrepid) 2F MODE OF ACTION GROUP NUMBER ¹ : 18A COMMENTS: Provides suppression of cutworms.	4–10 fl oz	4	1
B. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products) MODE OF ACTION GROUP NUMBER ¹ : 11	Label rates	4	0
C. CHLORPYRIFOS* (Lorsban Advanced) (Lorsban 15G) MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not make more than 1 application of 15G per year. Avoid drift and tailwater runoff into surface waters or choose alternative materials.	2 pt 8 oz/1000 row ft	24 24	30–tops and roots 30
D. METHOMYL* (Lannate) LV MODE OF ACTION GROUP NUMBER ¹ : 1A	1.5 pt	48	21–roots 30–tops
E. CARBARYL* (Sevin) 80S MODE OF ACTION GROUP NUMBER ¹ : 1A	1.87 lb	12	28–roots and forage

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irc-online.org.

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

EMPOASCA LEAFHOPPERS (1/10)

Scientific Names: *Empoasca fabae* and *Empoasca solana*

DESCRIPTION OF THE PESTS

The two species *Empoasca fabae* and *E. solana* constitute over 90% of the *Empoasca* species found in sugarbeet. They are nearly identical morphologically and can only be distinguished by experts. The damage they cause is also nearly identical as are the treatment guidelines.

Empoasca leafhoppers are small (0.125 inch long), bright green, wedge-shaped insects. They may be distinguished from the green form of beet leafhopper by the lack of dark markings on the body. The small, wingless nymphs (immatures) are also wedge-shaped and green and move rapidly forward, backward, and from side to side. Both adults and immatures are found primarily on the underside of leaves.

DAMAGE

Empoasca leafhoppers cause a symptom known as hopperburn in which the leaf margins turn yellow, particularly at the leaf tip, and these areas soon become necrotic. The entire leaf may become yellowed and the symptoms often resemble virus symptoms. The presence of adult and immature leafhoppers on the undersurface of the leaf serve to distinguish leafhopper injury from virus symptoms or mineral deficiencies. Empoasca leafhoppers do not spread beet curly top virus.

MANAGEMENT

Sample for Empoasca leafhoppers by counting the number of adults and nymphs per leaf. Examine a minimum of 10 leaves from 10 plants in at least four areas of the field. Pick fully expanded leaves, avoiding older leaves or leaves in contact with the ground. Also, select leaves that are shaded by other leaves because leafhoppers try to avoid the sun. Leafhoppers are found on the under surface of the leaf, so turn the leaf over and *quickly* count the number of leafhoppers; both adults and immatures can run very fast so you must be quick. Before starting your actual count, look at and count three to four leaves so that you will know what the leafhoppers look like, particularly the small ones, and how they behave. Then begin your sampling and actual counts.

Apply treatments when leafhoppers (both nymphs and adults) reach 10 to 15 per leaf. Use the lower number for fields 2 to 3 months up to several months from harvest. Use the higher number for fields within 1 to 2 months of harvest. Do not treat if fields are within 2 to 3 weeks of harvest.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. PHORATE* (Thimet) 20G MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not feed tops to livestock. Do not place Thimet granules in contact with seed.	4.5 oz/1000 ft. row	72	30
B. OXYDEMETON-METHYL* (MSR Spray Concentrate) MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: No more than 2 applications/year.	1.5–3 pt	72	30—tops and roots
C. NALED (Dibrom 8) MODE OF ACTION GROUP NUMBER ¹ : 1B	1 pt	48	2
D. ESFENVALERATE* (Asana XL) MODE OF ACTION GROUP NUMBER ¹ : 3	5.8–9.6 fl oz	12	21

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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.

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

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.iraac-online.org.

FLEA BEETLES (1/10)

Scientific Names: Potato flea beetle: *Epitrix cucumeris*
 Threespotted flea beetle: *Disonycha triangularis*
 Palestriped flea beetle: *Systema blanda*
 Tuber flea beetle: *Epitrix tuberis*

DESCRIPTION OF THE PESTS

The potato flea beetle is a small (0.065 inch), shiny black beetle. The threespotted flea beetle is two to three times larger and has an orange-colored thorax on which are three prominent dark spots. The palestriped flea beetle is about twice as large as the potato flea beetle. It is dark brown and has a longitudinal creamy white stripe on each wing cover. The tuber flea beetle is about the same size as the potato flea beetle and is also black and somewhat shiny, but has even rows of small indentations on the wing covers. All of the flea beetles have enlarged hind legs and jump vigorously when disturbed, thus the name flea beetle.

DAMAGE

Flea beetle damage is generally a concern only during the cotyledon and early leaf development stages. Damage is caused by adults and consists of numerous small rounded or irregular holes eaten in leaves so that leaves appear to have been peppered with small shot. In young plants this feeding damage can be very serious and result in plant death, thus reducing stands. In addition to adult damage, larvae of the palestriped flea beetle feeds on roots of young plants as well as on germinating seeds.

MANAGEMENT

Keep fields weed-free, particularly free of field bindweed and mustard, which are preferred hosts of flea beetles. Replant heavily damaged fields. No economic thresholds are available, but consider treatments, especially on young plants, if damage reaches a moderate level. Once plants are well established, flea beetles rarely cause sufficient foliar damage to justify treatment.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. METHOMYL* (Lannate)LV (Lannate) SP MODE OF ACTION GROUP NUMBER ¹ : 1A COMMENTS: Preharvest interval is 21 days for roots, 30 days for tops.	0.75–3 pt 0.25–1 lb	48 48	see comments see comments
B. CARBARYL* (Sevin) XLR Plus MODE OF ACTION GROUP NUMBER ¹ : 1A	1–1.5 qt	12	28—roots and forage

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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.

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

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

GRASSHOPPERS (1/10)

Scientific Name: *Melanoplus* spp.

DESCRIPTION OF THE PEST

Several species of grasshoppers may attack sugarbeets. Both adults and nymphs can cause damage. Injury is more likely near the foothill rangeland; however, grasshoppers can migrate great distances.

DAMAGE

Grasshoppers consume foliage, and if infestations are severe, may defoliate entire fields.

MANAGEMENT

A large contingent of natural enemies serve to hold grasshopper populations in check most years. However, in outbreak years and particularly after an invasion, other intervention will likely be needed. Because most grasshopper problems begin outside of the field, migrating invaders should be monitored closely. Apply treatment if and when a field is invaded.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. CARBARYL (Sevin 5 Bait)	30 lb	12	28 roots / forage
MODE OF ACTION GROUP NUMBER ¹ : 1A			
COMMENTS: Repeat applications as necessary up to a total of 2 times/year but not more often than 14 days apart.			

- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

LEAFMINERS (11/05)

Scientific Name: *Liriomyza* spp.

DESCRIPTION OF THE PEST

Leafminer adults are small flies with yellow and black markings. Females lay eggs on the surface of the leaves. When eggs hatch the larvae burrow into the leaves and feed on plant tissue. The larvae are small, legless maggots that are frequently found next to main veins.

DAMAGE

Both larvae and adults cause damage to plants. Larval feeding results in slender, winding trails on the leaves, which form large, white blotches when mining becomes severe. Adults damage plants by carving small pits on the leaf surface with their ovipositors and feeding on plant exudates. There may be as many as 100 feeding punctures on a single leaf. Around 5% of these punctures may contain actively feeding larvae.

MANAGEMENT

The larvae and adults are most active in spring, with several generations that follow in quick succession. Natural enemies can provide good control of the pea leafminers, and 50 to 90% parasitism of the larvae is not unusual. Several species of parasitic wasps from the genera *Diglyphus*, *Opius*, and *Dacnusa* attack leafminer larvae. Some of these species are commercially available.

No economic thresholds have been established, though plants appear to outgrow feeding damage by larvae and adults, and treatment is not usually required.

SALTMARSH CATERPILLAR (1/10)

Scientific Name: *Estigmene acrea*

DESCRIPTION OF THE PEST

Saltmarsh caterpillar is one of the woollybear caterpillars that has long hairs covering the entire body. Their hairs are generally of sufficient density as to completely hide the skin. They are typically black at each end with a median band in between of brown or reddish brown hairs. They also exhibit yellowish spots on the sides. The hairs are called urticarial hairs and may produce a stinging dermatitis (rash) on the skin of sensitive individuals.

DAMAGE

Caterpillars eat leaves. Young caterpillars skeletonize leaves while large, older caterpillars consume all of the leaf except the major veins. Small larvae are usually found feeding in groups on the underside of the leaves.

MANAGEMENT

Biological Control

The eggs are attacked by a number of predators and parasites. While the dense body hairs on the larvae effectively deter some of the potential predators and parasites, larvae are attacked by several diseases.

Monitoring and Treatment Decisions

No economic thresholds have been developed for saltmarsh caterpillars, which tend to be somewhat cyclic in their nature, with damaging populations occurring every 3 to 4 years. While present in other years, numbers are generally low, and severe injury rarely occurs.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A.	BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products) MODE OF ACTION GROUP NUMBER ¹ : 11	Label rates	4	0
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‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

SEEDCORN MAGGOT (1/10)

Scientific Name: *Delia platura*

DESCRIPTION OF THE PEST

Larvae of the seedcorn maggot are small, pale or dirty-colored, yellowish white, legless maggots with tough skin. Adults are grayish brown flies and about 0.20 inch long.

DAMAGE

Seedcorn maggots feed on the seed and may destroy it. Injury is most severe during wet, cold periods.

MANAGEMENT

In California, seedcorn maggots are only occasional pests. They are usually associated with high levels of organic matter in fields that have recently had a cover crop disked in.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. PHORATE* (Thimet) 20G MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Apply at planting; do not place granules in direct contact with seed. Do not feed tops to livestock.	4.5 oz/1000 row ft	72	30
B. CHLORPYRIFOS (Lorsban) 15G MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: In-furrow at planting time. T-band or band at planting or postemergence.	8 oz/1000 row ft	24	30

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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.

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

1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

SPIDER MITES (1/10)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*
 Carmine spider mite: *Tetranychus cinnabarinus*

DESCRIPTION OF THE PESTS

Spider mites resemble tiny spiders, no larger than a pinhead. Nearly identical in appearance, the carmine mite occurs on sugarbeets primarily in the Imperial Valley and the twospotted spider mite is more common in other beet-growing areas of California. When newly hatched, spider mites have three pairs of legs, but as they mature, they develop four pairs. They vary in color from nearly transparent to yellowish, greenish, or even red. They have two darkly pigmented spots, one on each side of the body. While visible to the unaided eye, they are best seen and identified with the use of a 10X hand lens. Both species cause similar damage and are managed in the same manner.

DAMAGE

Mites feed on the undersurface of the leaf. They puncture cells on the leaf surface and feed on the sap from leaves, leaving them blotched with white or pale yellow spots, which range in size from mere specks to larger areas as the specks coalesce. The damage is visible on both the upper and lower surface of the leaf. Spider mites spin very fine webs over the surface that become prominent as the number of mites per leaf increases. Severe infestation can cause defoliation.

MANAGEMENT

Spider mites are usually controlled by predatory insects and mites. Outbreaks are often the result of plant stress or dusty conditions. Mature sugarbeets can tolerate dozens to hundreds of mites per leaf without significant reductions in yield or quality. Treatments may be necessary on early- and mid-season sugarbeets although treatment thresholds have not been established.

Biological Control

Spider mites have numerous predators, including lacewings, assassin bugs, damsel bugs, minute pirate bugs, bigeyed bugs, and sixspotted thrips. Predatory mites are often found attacking spider mites. Predatory mites can be distinguished from spider mites by their slightly larger size and a more flattened, pear-shaped appearance. Predatory mites are clear, lacking any spots or coloration. These natural enemies can keep spider mite populations in check and may bring spider mites under control. Always check for their presence when you find mites in your fields.

Cultural Control

Mites are more serious on stressed plants, particularly water-stressed or dust-covered plants. Outbreaks may occur as a result of foliar applications of organophosphates, carbamates, and pyrethroids used to control other pests such as armyworms. Avoid using these insecticides where possible and observe good cultural practices including adequate nutrition and irrigation.

Monitoring and Treatment Decisions

There are no economic thresholds for spider mites. If numbers continue to increase in spite of the presence of biological control agents, and injury becomes severe, treatments might be necessary.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. NALED (Dibrom 8)	1 pt	48	2
MODE OF ACTION GROUP NUMBER ¹ : 1B			
COMMENTS: May give good initial control, but resurgence (primarily from hatching eggs) can be a serious problem.			

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
B. SULFUR DUST# MODE OF ACTION: Unknown. An inorganic insecticide.	35–40 lb	24	NA
C. MICRONIZED SULFUR# (Microthiol Disperss) MODE OF ACTION: Unknown. An inorganic insecticide.	5–10 lb	24	NA

- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.
- # Acceptable for use on organically grown produce.
- NA Not applicable.

WEBWORMS (1/10)

Scientific Names: Beet webworm: *Loxostege sticticalis*
 Alfalfa webworm: *Loxostege cereralis*
 Garden webworm: *Achyra rantalis*

DESCRIPTION OF THE PESTS

Webworms overwinter as larvae or pupae and emerge in early spring. Adults are small buff to smoky brown colored moths that are active at night. They may be readily observed flying out of the foliage during the day as you walk through the field. Eggs are small, yellow or green in color, and laid in groups of 2 to 20 on the underside of leaves. Beet webworm eggs are laid end to end, while those of the alfalfa webworm are in overlapping groups. The beet webworm is dark green on hatching; mature larvae are about 1.5 inches long and olive green in color with a dark band running along the center of the back and lighter stripes on each side. The alfalfa webworm is yellowish to dark green with a broad light-colored stripe down the back and a darker stripe parallel to the light stripe. The garden webworm is also yellowish to green with a pale double stripe along the center of the back and a lighter line on each side of the body. The body also has numerous distinct black spots.

DAMAGE

Damage caused by the three species of webworms is nearly identical. They consume large amounts of foliage by skeletonizing leaves, and can completely defoliate a field in a very short period of time. As they devour leaves, webworms spin a web, drawing leaves together or folding individual leaves together to form a tube in which they hide when disturbed.

MANAGEMENT

Webworms are only occasional problems in sugarbeets. Plants can tolerate considerable defoliation and many biological control agents attack webworms. However, fields with populations of webworms should be closely monitored. If management is needed, choose materials such as *Bacillus thuringiensis* or spinosad that have low impact on natural enemies.

Biological Control

Numerous parasites and predators have been reported on webworms. However, it is doubtful that any of these agents are capable of regulating webworm populations.

Cultural Control

Injury and defoliation appear to be worse in weedy fields. Therefore, keep fields weed-free, particularly free from pigweed and lambsquarters.

Monitoring and Treatment Decisions

No treatment thresholds are available for webworms. As with armyworms, the plants can tolerate considerable defoliation without yield loss. However, because of the rapidity with which webworm can defoliate plants, closely monitor fields in which webworms are active and apply a treatment if defoliation continues.

Common name (trade name)	Amount per acre	R.E.I.# (hours)	P.H.I.# (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. METHOXYFENOZIDE (Intrepid) 2F MODE OF ACTION GROUP NUMBER ¹ : 18A	4–10 fl oz	4	1
B. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products) MODE OF ACTION GROUP NUMBER ¹ : 11	Label rates	4	0

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
C. SPINOSAD (Entrust)‡ (Success)	1.5–3 oz 4.5–6 fl oz	4 4	3 3
MODE OF ACTION GROUP NUMBER ¹ : 5 COMMENTS: Do not apply more than 0.33 lb spinosad/acre/crop.			
D. METHOMYL* (Lannate) LV (Lannate) SP	0.75–3 pt 0.25–1 lb	48 48	see comments see comments
MODE OF ACTION GROUP NUMBER ¹ : 1A COMMENTS: Preharvest interval is 21 days for roots, 30 days for tops.			

- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.
- 1 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.
- * Permit required from county agricultural commissioner for purchase or use.

WHITEFLIES (1/10)

Scientific Names: Silverleaf whitefly: *Bemisia argentifolii* (aka *B. tabaci*, Biotype B)
Sweetpotato whitefly: *Bemisia tabaci*

DESCRIPTION OF THE PESTS

Whitefly adults are tiny (0.06 inch) yellowish insects with white wings. They are found mostly on the undersides of leaves. The tiny oval eggs hatch into a first larval stage that has legs and antennae, which will be lost after the first molt. Nymphs are soft, oval, flat, and remain fixed at one feeding site.

Silverleaf whitefly adults immigrating into beet fields may build up to extremely high numbers on the underside of leaves. They fly in great clouds when disturbed.

DAMAGE

In the Imperial Valley, silverleaf whiteflies and sweetpotato whiteflies will feed and deposit eggs on sugarbeets, but the nymphs do not survive to the adult stage. In high populations, whiteflies can damage sugarbeet by sucking sap from plants and causing stunting and wilting. Large populations along with very hot weather may kill young plants. Whiteflies do not appear to be a problem in the San Joaquin Valley. While large numbers of adults may be seen on foliage in fall, especially in sugarbeet fields adjacent to cotton, they do not lay eggs on sugarbeet leaves.

The sweetpotato whitefly is a vector of *Lettuce infectious yellows virus*, an extremely destructive virus of sugarbeet; the silverleaf whitefly, however, is not. The sweetpotato whitefly has been displaced by the silverleaf whitefly, and lettuce infectious yellows is currently not a major concern. Silverleaf whitefly does inject a toxin into the plant as it feeds, which causes the leaf petioles to turn white. Plants recover, however, when whitefly populations decrease with cooler weather in fall.

MANAGEMENT

Whiteflies only periodically need to be managed during fall on young sugarbeets, primarily in the Imperial Valley. Parasites and predators, in conjunction with not planting sugarbeets next to preferred whitefly hosts, are usually sufficient to keep whitefly populations below damaging levels.

Biological Control

Several wasps, including species in the *Encarsia* and *Eretmocerus* genera, parasitize whiteflies. Whitefly nymphs are also preyed upon by bigeyed bugs, lacewing larvae, and lady beetles. Silverleaf whitefly is an introduced pest that has escaped its natural enemies. Some indigenous native parasites and predators do attack it but do not keep it below damaging numbers. The lady beetle *Delphastus pusillus* is being introduced into southern California to assist in biological control.

Cultural Control

When possible, plant sugarbeets at least 1/2 mile upwind from key silverleaf whitefly hosts such as melons, cole crops, and cotton. Maintain good sanitation in areas of winter and spring host crops and weeds by destroying and removing all crop residues as soon as possible. Control weeds in noncrop areas including head rows and fallow fields, and harvest alfalfa on as short a schedule as possible.

Monitoring and Treatment Decisions

Routinely check field margins for whiteflies; these areas are usually infested first. Be especially alert for rapid population buildup when nearby host crops are in decline. Allow beneficials an opportunity to control light whitefly infestations. If higher populations are present at the field margins than the field centers, then treat only the field margins. This approach will reduce treatment costs and help preserve beneficials in the field.

In the Imperial Valley, treatment may be necessary in September if high populations of this pest are immigrating into sugarbeet. No economic thresholds are established. Insecticidal soaps and oils are not as effective as endosulfan and require frequent applications and good coverage. While good coverage is essential with oils and soaps, phytotoxicity may be a problem.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. INSECTICIDAL SOAP# (M-Pede)	1% solution or less	12	NA
MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
B. NARROW RANGE OILS# (Sunspray)	1% solution or less	4	NA
MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
COMMENTS: Do not exceed 2 gal product/ acre.			

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- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.
- NA Not applicable.

WIREWORMS (1/10)

Scientific Names: *Agriotes* spp. and *Limoniuss* spp.

DESCRIPTION OF THE PESTS

Wireworms are beetle larvae that are found in soil where they feed on roots. They are yellowish brown, thin worms that have a shiny, tough skin. Adults of the wireworms are click beetles, so named because their elongated bodies are capable of producing a clicking sound. Only the larval stage causes damage.

DAMAGE

Wireworms feed on roots of emerging plants, killing the seedlings and reducing the stand. As plants mature, wireworms may girdle the stem. Be sure to dig around the plant and look for wireworm larvae to confirm that they are the cause of injury.

MANAGEMENT

Cultural Control

In fields known to contain wireworm larvae, fallow during summer with frequent tillage (springtooth or disk). Damage from wireworm infestations to the crop when it is in the seedling stage can sometimes be reduced by replanting. Rotate to nonhost crops if possible; contact your county farm advisor for information regarding nonhosts. Do not plant a susceptible host crop following a crop that has had a heavy infestation of wireworm without fallowing, tilling, or applying a pesticide.

Monitoring and Treatment Decisions

Wireworm infestations are difficult to detect before visible plant injury occurs. They are most likely to be found in a sugarbeet field when sugarbeet follows a long-term legume crop or natural or temporary pasture.

Chemical controls are ineffective or impossible to apply to wireworms attacking a standing crop. If used, chemicals must be applied as preplant or seed treatments.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in the order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees as well as the environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. CHLORPYRIFOS (Lorsban) 15G MODE OF ACTION GROUP NUMBER ¹ : 1B COMMENTS: Offers suppression only. Apply in-furrow at planting time. T-band or band at planting or postemergence.	8 oz/1000 row ft	24	30
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- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Rotate chemicals 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; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action Group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see www.irac-online.org.

Diseases

(Section reviewed 11/05)

APHID-BORNE VIRUSES (1/10)

Pathogens: Beet yellows virus (BYV), Beet western yellows virus (BWYV), Beet chlorosis virus (BChV) and Beet mosaic virus (BtMV)

SYMPTOMS AND SIGNS

Symptoms of *Beet yellows virus*, *Beet western yellow virus* and *Beet chlorosis virus* are very similar and typically first observed on older leaves that begin to yellow in the area between the veins where small reddish brown spots often appear, giving the leaves a distinct bronze cast. Eventually leaves become thick, leathery, and brittle. Severe strains of *Beet yellows virus* first cause a vein etching of the heart leaves, followed by yellowing of entire leaf blades or sectors of older leaves. The vein-etching symptom is only apparent for a brief period, but its presence is a strong indicator of *Beet yellows virus* infection, because the other aphid-transmitted viruses do not produce this symptom. When leaves are infected with *Beet mosaic virus*, young leaves are infected first and show a mosaic or mottled pattern that may disappear or fade as the leaves mature. Infections involving more than one aphid-transmitted virus have been observed in the field, and co-infections by *Beet yellow virus* and *Beet mosaic virus* can lead to increased disease severity if plants are infected as seedlings.

COMMENTS ON THE DISEASES

These viruses were common problems when sugarbeets were produced in the Central Valley, but they are not as common in the Imperial Valley, which is the sole remaining area of sugarbeet production in California. These viruses are vectored primarily by the green peach aphid, *Myzus persicae*, and the black bean aphid, *Aphis fabae*. Other aphids, including the bird cherry-oat aphid and blue alfalfa aphid, have been shown to vector *Beet yellows virus*, but their significance in the spread of the disease is still unclear.

The aphids obtain *Beet yellows virus* and *Beet mosaic virus* primarily from overwintering beets; *Beet western yellows virus* and *Beet chlorosis virus* have a very wide host range, however, including plants in the crucifer and composite families. Disease potential is greatest in years when aphids are able to colonize beets early in spring and multiply rapidly; crop losses can be considerable, ranging up to 2% or more per week of infection when plants are infected with *Beet yellows virus*. Plants infected at early stages of development suffer the heaviest losses; late infections (4–6 weeks before harvest) may not cause significant yield loss.

MANAGEMENT

To control this disease, eliminate overwintering hosts (beet-free periods) and plant to avoid migrating aphids (vector-free period generally in May and June). Fields planted 10 to 20 miles from old plantings generally avoid economic losses, and a barrier of even 5 miles significantly reduces infection. This is especially true for *Beet yellows virus*, which has the most severe effect on yield when it infects the crop during the seedling stage. For additional information see the section on green peach aphid.

Tolerant and resistant varieties are being developed and may be commercially available for areas where aphid vectors and serious virus infections are endemic; check with your field representative or farm advisor for the most up-to-date information.

Comments on Control

Because of the closure of sugarbeet factories in Woodland and Tracy, the threat of beet yellowing viruses is limited to an area immediately south of the Delta where crops are planted in spring and then overwintered. The source of the virus in this area may be naturalized populations of wild beet in the Delta region. The disease-free program, postponing planting in spring until after the most significant danger from aphid flights, still applies in this area. Monitor overwintered fields in spring, and analyze samples for yellowing viruses before planting beets on nearby land. If *Beet yellows virus* is not detected, earlier planting dates are allowed.

CERCOSPORA LEAF SPOT (1/10)

Pathogen: *Cercospora beticola*

SYMPTOMS AND SIGNS

Symptoms of *Cercospora* leaf spot first appear as individual, circular spots that are tan to light brown with reddish purple borders. As the disease progresses, individual spots coalesce. Heavily infected leaves first become yellow and eventually turn brown and necrotic. Blighted leaves soon collapse and fall to the ground, but remain attached to the crown. Heart leaves are usually less severely affected and remain green.

COMMENTS ON THE DISEASE

This disease was primarily a problem on sugarbeets grown in the southeastern portion of the San Joaquin Valley and is not common in the Imperial Valley.

Warm nights combine with high humidity in irrigated fields to provide an ideal environment for disease development. Optimum daytime temperatures for disease development are 77° to 95°F (25°–35°C) with night temperatures above 61°F (16°C) and a relative humidity of 90 to 95%. The primary source of inoculum is residue from a previously infected crop, but the fungus can be carried on seed and is also hosted by numerous weeds. Spores produced by the fungus are dispersed by splashing rain and may also be carried by wind to susceptible sugarbeet leaves.

MANAGEMENT

This disease is not generally a problem in the Imperial Valley and is not normally treated for there. Varieties vary considerably in resistance, with the highest-yielding current varieties having the least resistance. Growers planting sugarbeets in late fall or early spring for an early fall harvest are most likely to be affected by *Cercospora* and should use a more resistant variety if possible.

To effectively eliminate inoculum from a field, plant sugarbeets in a 3-year rotation with nonhosts and plow to incorporate crop residues. Avoid planting a new sugarbeet field adjacent to fields planted to beets the previous season. When sprinkler irrigation is used, run sets so that windblown mist does not keep leaves wet for longer than 24 hours.

CURLY TOP (1/10)

Pathogens: Beet curly top virus (BCTV), Beet severe curly top virus (BSCTV), Beet mild curly top virus (BMCTV)

SYMPTOMS AND SIGNS

Leaves are dwarfed, crinkled, and rolled upward and inward. Veins on the lower side of infected leaves are irregularly swollen with bumps. If large roots are cut crosswise, dark rings of vascular tissue can be seen. Young roots of infected plants are dwarfed, and rootlets tend to become twisted and distorted and are often killed. Death of rootlets is followed by production of new rootlets, leading to a "hairy root" symptom that can resemble symptoms of the unrelated disease, rhizomania.

COMMENTS ON THE DISEASE

Beet curly top virus is vectored by the beet leafhopper, *Circulifer tenellus*, which has an extensive host range, a high reproductive capacity, and can migrate long distances from its breeding grounds in the coastal foothills and desert areas to cultivated areas. The leafhopper overwinters on a wide range of annual and perennial weeds and readily acquires the virus when it feeds on infected plants (for more information, see BEET LEAFHOPPER). Once acquired, the vector can usually transmit the virus for the rest of its life. In spring, beet leafhopper migrates to agricultural lands when the overwintering host plants dry out. Severity of curly top disease in sugarbeet depends on climatic factors that influence the prevalence of weed hosts of the virus and the reproductive capacity and migration of the leafhopper vector. *Beet curly top virus* also can cause significant losses in tomatoes, beans, peppers, and occasionally cucurbits.

MANAGEMENT

Curly top is not generally a problem in the Imperial Valley. In other areas, grow resistant varieties in virus-prone areas, especially along the west side of the San Joaquin Valley. In addition, control overwintered weeds and other plants that serve as hosts for the leafhopper vector or the virus.

ERWINIA SOFT ROT (11/05)

Pathogen: *Erwinia betavasculorum*

SYMPTOMS AND SIGNS

The disease is not easy to detect until the rot is well advanced. The vascular tissue of the root becomes discolored and a pinkish to red brown rot develops. Root symptoms vary from a soft rot to a dry rot; the root may become hollow without dying. As the disease progresses, plants wilt. Occasionally brown, oozing lesions occur on petioles and crown.

COMMENTS ON THE DISEASE

Erwinia soft rot can cause serious damage. Disease potential is greatest when temperatures are in the range of 77° to 86°F (25° to 30°C). The bacterium is soilborne and infects plants if infested soil gets into the beet crown from dirty farm machinery, splashing water, insects, or other means. It invades the plant through an injury or wound to the crown or leaves and enters the vascular vessels of the root and petioles.

MANAGEMENT

Beet varieties vary widely in their resistance or susceptibility to this pathogen. Commercial varieties in California are tested for soft-rot resistance: whenever possible, use resistant varieties. Excessive amounts of nitrogen fertilizer encourage *Erwinia*. Use the minimum amount of fertilizer necessary to achieve yield goals. Follow cultural practices that promote good soil structure. Avoid throwing soil and plant debris into beet crowns during cultivation, and adjust implements to minimize injury to crown and tops.

PHYTOPHTHORA AND PYTHIUM ROOT ROTS (11/05)

Pathogens: *Phytophthora drechsleri* and *Pythium aphanidermatum*

SYMPTOMS AND SIGNS

Symptoms for *Phytophthora* and *Pythium* root rots are different, but management of the two diseases is the same. Plants with *Phytophthora* root rot appear wilted in the early stages of disease development and eventually wilt permanently, especially when hot, dry conditions prevail. Initial infection occurs at the base of lateral roots, causing a small necrotic lesion. As the disease progresses, it appears as a wet root rot and advances upward toward the crown. Rotted tissue turns brown with a distinguishing blackish margin adjacent to healthy tissue.

Pythium root rot is a wet rot that causes the taproots of mature beets to become brown to black. As the disease progresses foliage wilts, leaves yellow, and older lower leaves die. Older leaves may have blackened water-soaked lesions at the base of the petiole.

COMMENTS ON THE DISEASE

Phytophthora drechsleri and *Pythium aphanidermatum* are soilborne fungi. The disease is most common in fields where sugarbeets are exposed to excessive soil moisture, particularly following heat or moisture stress. Optimum temperatures for disease development are 82° to 88°F (28° to 31°C). Stand reduction can occur if seedlings are infected and stressed or when older plants are infected later in the season. Heavily infected sugarbeet crops have a low sugar concentration and high level of impurities at harvest.

MANAGEMENT

Provide adequate field drainage and prevent excessive seepage from irrigation canals. Most importantly avoid overirrigating, especially during periods of high temperatures. In soils where drainage is a problem, plant in raised beds, use sprinkler irrigation, and rotate to nonsusceptible crops to reduce inoculum potential. Carefully adjust cultivating and thinning equipment to reduce mechanical injury to feeder roots.

POWDERY MILDEW (1/10)

Pathogen: *Erysiphe polygoni*

SYMPTOMS AND SIGNS

The first signs of powdery mildew are small, white powdery spots that appear usually on the under surface of older leaves when sugarbeet plants are 2 to 6 months old. Under suitable conditions, the fungus spreads rapidly over the entire surface of the leaf, and eventually to all leaves on affected plants. Older leaves may yellow and eventually become necrotic and die.

COMMENTS ON THE DISEASE

Powdery mildew is an annual problem on sugarbeet in California. The fungus overwinters on sugarbeet and other *Beta* species such as swiss chard, table beets and wild *Beta* species that grow throughout the winter. Ideal conditions for disease development are warm, dry weather; optimum temperatures for growth of the fungus are between 60° and 86°F (15° and 30°C). Very high daily temperatures of 100°F (38°C) or higher tend to arrest disease development. Following initial infection, the fungus grows over the surface of the leaf and produces asexual spores (conidia), which give the leaf a powdery appearance. The conidia are airborne and can be carried considerable distances to start new infections. If the disease is not controlled, 20 to 35% loss in sugar yield can occur.

MANAGEMENT

Currently, varieties with moderate resistance are available. Use these varieties in combination with chemical control measures. Apply a fungicide before, if possible, or when the first small, white powdery spots appear on the undersurface of leaves. Repeated applications are necessary at 3- to 6-week intervals if the disease reappears. Good coverage of the beet leaf surfaces is essential.

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in order of usefulness in an IPM Program, taking into account efficacy. Also, consider information relating to environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A.	SULFUR# (Dust) (Micronized wettable)	30 lb 10 lb	24 24	0 0
	MODE OF ACTION GROUP NAME (NUMBER ¹): Multi-site contact (M2)			
	COMMENTS: Other types of sulfurs may be used.			
B.	PYRACLOSTROBIN (Headline)	9–12 fl oz	12	7
	MODE OF ACTION GROUP NAME (NUMBER ¹): Quinone outside inhibitor (11)			
	COMMENTS: Maximum use per year is 48 oz/acre, but do not reapply. Alternate use with other mode of action fungicides to avoid the rapid development of resistance by the disease organism.			
C.	AZOXYSTROBIN (Quadris)	9.2–15.4 fl oz	4	0
	MODE OF ACTION GROUP NAME (NUMBER ¹): Quinone outside inhibitor (11)			

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1,4,9,11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number. For more information, see www.frac.info.

RHIZOCTONIA ROOT AND CROWN ROT (11/05)

Pathogen: *Rhizoctonia solani*

SYMPTOMS AND SIGNS

Aboveground symptoms on older plants include sudden yellowing and wilting of foliage. Leaf petioles die near the crown and wilted leaves collapse and die, forming a dry, brown rosette that persists throughout the growing season. Exposed areas of infected roots are often covered with masses of brown mycelium. The fungus causes a characteristic dry rot that is brown with deep fissures at or near the crown. The root and crown are partially or completely destroyed.

Rhizoctonia solani also attacks sugarbeet in the seedling stage, causing damping-off (see section on Seedling Diseases).

COMMENTS ON THE DISEASE

Rhizoctonia root and crown rot, caused by a soilborne fungus, is a common root disease of sugarbeet. The fungus is widespread, has many crop hosts, and survives on plant debris in soil as small, resting structures called sclerotia. This disease is most common during spring and summer when conditions are warm (77° to 92°F, 25° to 33°C) and soils are moist. The fungus grows through the soil and infects the root and crown of plants. Rhizoctonia occurs in most soil types, but is most severe in heavy, poorly drained soils where water collects.

MANAGEMENT

Check with your farm advisor or field representative on the latest information concerning the availability of resistant varieties in California; if available, use them. Follow good tillage, irrigation, and fertilization practices to promote good crop growth and adequate soil drainage. Plant sugarbeet in rotation with corn or small grains, and when cultivating, avoid throwing dirt into plant crowns.

RHIZOMANIA (1/10)

Pathogen: Beet necrotic yellow vein virus (BNYVV)

SYMPTOMS AND SIGNS

Rhizomania is characterized by root stunting and a proliferation of lateral rootlets on the main taproot that give the root a bearded appearance. The storage root is often constricted (turnip-shaped) below the soil level and rotted. The vascular tissue of the taproot becomes discolored and appears as darkened rings when the taproot is cross-sectioned. These symptoms can resemble those caused by curly top disease, but the two are unrelated. Leaves of infected plants often exhibit a pale to bright yellowing of the leaves that can mimic a nitrogen deficiency. The necrotic yellow vein symptom associated with the virus name is rarely observed in the field. Leaves on the plant wilt, especially in periods of high water demand or following irrigation when the fungal vector of the disease is most active. At the beginning of summer, some leaves on plants may crinkle and bleach along veins, but these symptoms can disappear after a few weeks.

COMMENTS ON THE DISEASE

Rhizomania is one of the most destructive diseases of sugarbeet. The causal agent, *Beet necrotic yellow vein virus*, is transmitted by the soilborne fungus *Polymyxa betae*. Disease development is influenced by the fungus, which is enhanced by saturated soil conditions from rain, irrigation, or poor soil drainage and the warming of soil temperatures in spring. In infested fields, most sugarbeets are affected: roots are usually small, sugar yields are poor, and losses can be as high as 100%. Recent studies suggest that additional losses in fields with infected beets may be the result of secondary invasion by other root pathogens, such as *Phytophthora* or *Pythium*.

MANAGEMENT

It is assumed that all commercial sugarbeet fields in California now have rhizomania. Only plant rhizomania-resistant varieties. Current resistant varieties are very high yielding and have provided protection over the last decade; however, a resistance-breaking pathotype was observed in the Imperial Valley in 2003 and is slowly spreading. It may appear in the San Joaquin Valley in the future. Sources of resistance to the new pathotype have been identified and in time may be required in some areas. Consult with seed sales representatives for varietal recommendations. Avoid planting sugarbeets 2 years in a row in the same field, and avoid fields known to contain the new strain until effective new resistant varieties are available.

RHIZOPUS ROOT ROT (11/05)

Pathogens: *Rhizopus stolonifer* and *Rhizopus arrhizus*

SYMPTOMS AND SIGNS

This disease first appears as a temporary wilting of foliage during periods of stress; as the disease advances wilting becomes permanent. After death of the beet, the foliage and root become very brittle and dry. Infected root tissue appears gray brown with darker vascular rings. The disease generally progresses downward with the infected tissue becoming dark and spongy. The taproot can eventually be completely consumed with white mycelium. Black sporangia (spores) are produced on the white mycelium, giving the fungal mass a dark appearance. Often the fungus will decay the internal tissue creating a cavity filled with a clear fluid. The roots may have an odor of acetic acid.

COMMENTS ON THE DISEASE

Rhizopus stolonifer and *R. arrhizus* are common in most agricultural soils throughout the world; in California, *R. arrhizus* is the more common species. In spite of their widedistribution, both fungi are weak sugarbeet pathogens and tend to only be a problem when the crop is compromised by some other factor such as excess soil moisture, crown injuries, or insect injury (cutworms, armyworms) to roots. While the symptoms caused by these species are identical, the optimum temperatures for disease development are different: *Rhizopus stolonifer* causes disease at low temperatures of 57° to 61°F, while high temperatures, 86° to 104°F, favor *R. arrhizus*.

MANAGEMENT

Avoid conditions that cause injury to the taproot. Control insects, see insect section for specific control measures for cutworms and armyworms.

SCLEROTIUM ROOT ROT (1/10)

Pathogen: *Sclerotium rolfsii*

SYMPTOMS AND SIGNS

Sclerotium root rot or southern root rot can be a very destructive disease of sugarbeet in some areas but is not generally a problem in the Imperial Valley. Symptoms appear as poor top growth with wilting occurring as the taproot is decayed by the fungus. Under high temperatures, plants will eventually wilt permanently. The pathogen is characterized by cottony mycelial growth on the surface of the tap root with small (1-3 mm) spherical sclerotia that are tan to dark tan when mature.

COMMENTS ON THE DISEASE

Sclerotium rolfsii is a soilborne fungus that survives in the soil as sclerotia, and has a host range of over 200 plant species. The disease is favored by moist soil conditions and high temperatures, 77° to 95°F. The fungus is spread through irrigation water and by cultivation equipment. Although the disease has been reported to occur in seedlings, temperatures are not generally conducive to disease development until later in the season. Frequently, *S. rolfsii* can cause significant disease losses that may occur just prior to harvest, late August to early September.

MANAGEMENT

There are no chemical control methods for managing this disease. Management can be best achieved by reducing inoculum buildup through crop rotation. Suggested crops to include in a rotation are alfalfa, wheat, barley, corn, or susceptible crops that do not require irrigation during warm weather conditions. Do not rotate beets with beans or other highly susceptible crops and avoid frequent irrigations during hot weather. Yield losses can be reduced through application of nitrogenous fertilizers that promote vigorous growth. Additionally, in fields where Sclerotium root rot has been identified, harvest early.

SEEDLING DISEASES (1/10)

Pathogens: *Pythium ultimum*, *P. aphanidermatum*, *Rhizoctonia solani*, *Aphanomyces cochlioides*

SYMPTOMS AND SIGNS

Seedling diseases can appear as seed decays, preemergence damping-off, or postemergence damping-off. Depending on the pathogen, most of the seed tissue is susceptible to infection, including nongerminated seed, germinating radicle, and emerging seedling up through the four- to six-leaf stage. Preemergence damping-off appears as darkened lesions on the emerging radicle and causes death of the radicle and seedling. Postemergence damping-off appears as a lesion on the seedling root or crown tissue, and causes the seedling to wilt, and possibly die. Plants that survive infection will not grow vigorously, resulting in greatly reduced yields.

COMMENTS ON THE DISEASE

The four pathogens that cause seedling diseases of sugarbeet are soilborne. *Pythium ultimum* is widespread in soil and attacks many crops. It infects unprotected seedlings at temperatures favorable for germination of beet seed (75° to 86°F), especially in winter and spring under conditions of warming soils with a high moisture content. It primarily causes a preemergence damping-off, but under moist conditions a postemergence damping-off may occur. *Pythium aphanidermatum* attacks seedlings only in warm soils (86° to 95°F, 30° to 35°C) with abundant soil moisture. *Rhizoctonia solani* and *Aphanomyces* spp. are problems primarily on emerged seedlings when temperatures are above 68° to 86°F.

MANAGEMENT

To minimize the potential for seedling diseases, use methods that favor rapid seedling emergence, including planting seeds as shallowly as practical and managing soil moisture (preplant irrigate, seed into moist soil and delay second irrigation until seedlings are beyond susceptible stages). Where *Rhizoctonia* is a problem, avoid planting beets following beans and other legumes, or cotton.

Buyseeds treated with protective fungicides that are effective against the pathogens in the soil to be planted. Seed treated with chloroneb has protection against *Rhizoctonia solani*. Mefenoxam-treated seed protects against *Pythium*. Currently, there are no registered fungicides in California that provide effective protection against *Aphanomyces* spp. In fields where *Aphanomyces* spp. are present, follow practices that enhance rapid germination, plant when the weather is cool, avoid saturated soil conditions in the seedbed, and rotate the crop with nonhost crops.

WHITEFLY-BORNE VIRUSES (1/10)

Pathogens: *Lettuce chlorosis virus* (LCV); *Lettuce infectious yellows virus* (LIYV)

SYMPTOMS AND SIGNS

Symptoms of these viruses are similar to those caused by aphid-transmitted *Beet yellows virus*. Early symptoms are a very mild mottle that later develop into interveinal yellowing or reddening. Affected plants are stunted. Vascular rings in roots are brown and mature taproots often appear to be pithy.

COMMENTS ON THE DISEASE

Lettuce infectious yellows used to be a problem on sugarbeets grown in the Imperial Valley. It was transmitted by the sweetpotato whitefly, *Bemisia tabaci*, which has been displaced by the silverleaf whitefly, *Bemisia argentifolii* (aka *B. tabaci*, Biotype B— a nonvector of this virus). Currently, lettuce infectious yellows is not a major concern and has not been observed in the field since the early 1990s. *Lettuce chlorosis virus* is not uncommon in the Imperial Valley, but it has not been associated with yield loss in sugarbeet.

MANAGEMENT

Lettuce infectious yellows is no longer a field problem in sugarbeets, and controls are not deemed necessary for lettuce chlorosis.

Nematodes

(Section updated 1/13)

Scientific Names: Sugarbeet cyst: *Heterodera schachtii*
 Root knot: *Meloidogyne incognita*, *M. javanica*, *M. arenaria*, *M. hapla*, and *M. chitwoodi*

DESCRIPTION OF THE PESTS

Plant-parasitic nematodes are microscopic roundworms that feed on plant roots. They survive in soil and plant tissues and several species may exist in a field. They have a wide host range, and vary in their environmental requirements and in the symptoms they induce. Apart from the nematodes listed above, several other species that occur in California, such as stubby root, sting, needle, spiral, sheath, stem and bulb, false root knot, and potato rot nematodes, have been reported as pests on sugarbeet in other parts of the world but are not known to be a factor in California sugarbeet production.

DAMAGE

Infestations of sugarbeet cyst nematode may be localized or spread over an entire field. In heavily-infested soils, seedling emergence may be delayed or seedlings may be killed before emergence, resulting in a reduced stand. Seedlings infested with sugarbeet cyst nematodes may be predisposed to secondary infection by soilborne fungi. This nematode is widespread in all former and present California sugarbeet growing areas, especially the Imperial Valley, central regions of the Central Valley, the Salinas Valley, and Monterey, Santa Barbara, and Ventura counties.

Meloidogyne incognita and *M. javanica* are the most damaging of root knot nematode species found in sugarbeet. *Meloidogyne hapla* is widely distributed, but not reported as a major problem on sugarbeet in California. *Meloidogyne chitwoodi* is found in Modoc and Siskiyou counties in northern California where its reproductive levels on sugarbeet are similar to those found on barley and less than those found on wheat, but no yield reductions have been reported.

SYMPTOMS

Symptoms described below are indicative of a nematode problem, but are not diagnostic as they could result from other causes as well. Infestations may occur without causing any aboveground symptoms.

Seedlings infested by sugarbeet cyst nematode may have longer petioles than normal, with green or yellow leaves depending on the severity of infestation. Plants are likely to be stunted and wilted. Typically, storage roots will not be well developed, and will have excessive fibrous roots. Mature female nematodes can be seen on the root surface as tiny, pinhead size, lemon-shaped bodies that are white in the earlier stages and turn into brown, egg-filled cysts on aging.

Heavy infestation by root knot nematodes in sandy soils may cause plants to wilt and collapse. Swellings (galls) can be seen on fibrous roots and the tap root, which may have a warty appearance.

FIELD EVALUATION

To make management decisions, it is critical to know the nematode species present and their population estimates. If a previous crop had problems caused by nematodes that are also pests of sugarbeet, population levels may be high enough to cause damage to an ensuing sugarbeet crop. If nematode species have not been identified previously, take soil samples and send them to a diagnostic laboratory for identification.

Before planting sugarbeet, take soil samples from within the root zone after harvest of the previous crop or preferably just before harvest. Divide the field into sampling blocks of 10 to 20 acres that are representative of cropping history, crop injury, or soil texture. Take several subsamples randomly from a block, mix them thoroughly and make a composite sample of about 1 quart (1 liter) for each block. Include roots in the sample if possible. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current or previous crop and the crop you intend to grow. Keep samples cool (do not freeze), and transport as soon as possible to a diagnostic laboratory. Farm advisors and PCAs can help you find a laboratory for extracting and identifying nematodes, and help in interpreting sample results.

MANAGEMENT

Sanitation

Thoroughly clean machinery and equipment with water between fields to mitigate the risk of spreading plant-parasitic nematodes to non-infested fields. This is especially important for *H. schachtii* as eggs in cysts are well protected against adverse environmental conditions.

Crop Rotation

Sugarbeet cyst nematode

The main host crops of *H. schachtii* are in the families Chenopodiaceae (e.g. garden beets, Swiss chard, spinach, mangold) and Brassicaceae (e.g. broccoli, radish, Brussels sprouts, rapini, cauliflower, kale, bok choy, mustard, canola, kohlrabi, and others). Several common weeds are also hosts such as common lambsquarters, shepherd's purse, pigweed, chickweed, dock, and others.

Rotation with nonhost crops is widely used to control sugarbeet cyst nematode. The interval between sugarbeet and other crops in rotation depends on the severity of infestation and local conditions influencing the nematode. In the Imperial Valley, fields are considered infested with *H. schachtii* if three or more cysts are found in a pint-size dump sample that is collected at the sugarbeet factory. Non-infested fields cannot be cropped to sugarbeets more than two years in a row and not more than four out of ten years. In infested fields, sugarbeets can be grown only once every four years.

This cropping program has been used effectively for half a century. The reason for the success is the natural decline in the population density of *H. schachtii* in the absence of host plants. Contact your farm advisor for help in developing a crop rotation program for sugarbeet cyst nematode. Be sure to destroy weed hosts during crop rotations.

Root knot nematode

Control of root knot nematodes by crop rotation is very difficult because of their wide host ranges. Nematode-resistant tomatoes can be grown if *Meloidogyne incognita*, *M. javanica*, or *M. arenaria* are present.

Planting Date

Planting when soil temperatures are below 50°F for *H. schachtii* and 65°F for *M. incognita* reduces damage and slows nematode population buildup.

Fallow

Weed-free fallow, which deprives nematodes of food, reduces most nematode populations. Fallow is most effective if soil is plowed and exposed to sun. Irrigation during the dry period further reduces nematode populations if proper weed control is maintained. The importance of the time of year in which to fallow as it relates to rate of decline of the nematode population is not well understood at this time.

Chemical Control

The damage threshold in the Imperial Valley for *H. schachtii* is one to two cyst nematode eggs per gram of soil. Thresholds have not been established in other areas of the state or for root knot nematodes, but consider treatment if nematodes are present and have caused problems in the past.

Common name (trade name)	Amount per acre	R.E.P.‡ (hours)	P.H.I.‡ (days)
A. METAM SODIUM* (Vapam, Sectagon 42)	50–75 gal	See label	NA
COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available. Contact your farm advisor for advice on the most effective application method for a particular situation.			

Common name (trade name)	Amount per acre	R.E.P.‡ (hours)	P.H.I.‡ (days)
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- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Fumigants no longer have an R.E.I., but a Restricted Entry Period (R.E.P.). REP can fluctuate, depending whether tarps are used or not and when tarps are cut and removed. Preharvest interval (P.H.I.) is the number of days from treatment to harvest. In some cases the REI or REP exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.
- * Permit required from county agricultural commissioner for purchase or use.
- NA Not applicable.

Weeds

(Section reviewed 11/05)

INTEGRATED WEED MANAGEMENT (1/10)

Sugarbeet is not a very competitive crop, thus weed control is mandatory, especially where sugarbeets are planted at final stand density and will not be thinned. Uncontrolled weeds can reduce sugarbeet yield by over 90%; even one barnyardgrass in 10 feet of row can cause about a 5 to 15% yield loss. Dense weeds make hoeing, the use of electronic thinners, cultivation, and harvest difficult.

In California, sugarbeets are planted from September through June. Weed populations in sugarbeet fields differ by season and location in the state. From October to February, during stand establishment until layby, winter annual weeds such as mustard species and annual bluegrass can be troublesome. Winter annual weeds die out in summer, but summer annuals begin germinating in March and continue throughout the summer growing season. Troublesome summer annual weeds include barnyardgrass, cocklebur, pigweed, velvetleaf, and knotweed. In some areas curly dock, a deep-rooted perennial, can be a problem. Overwintered beets can become infested with winter annuals again in fall.

Selection of the best weed management program is governed by several factors:

1. Geographic location, which determines planting date, weed spectrum, and irrigation or rainfall
2. Date of planting, which determines weed spectrum and irrigation or rainfall
3. Weed species present (or anticipated to be present), which determines choice of weed control method and choice of herbicides
4. Availability and cost of hand labor for weeding, which determines if hand weeding can be considered within the program
5. Availability of equipment, which determines how well cultivation can be conducted and if herbicides can be applied accurately and properly incorporated into soil, if required
6. Method of irrigation, which determines choice of herbicide and influences cultivation choices

Economically acceptable weed control can only be achieved with a management program that integrates several methods as no currently available weed control practice provides complete weed control in a sugarbeet crop. Band applications of an herbicide in the crop row, combined with between row cultivation(s), form the mainstay of a sugarbeet weed management program. This combination reduces the amount of herbicide used and minimizes the need for labor, which results in lower production costs and less herbicide being placed in the environment.

Herbicides

Because sugarbeet is a long-season crop that requires many months to grow, season-long weed control is difficult because early-season weed control may not last until harvest. Overwintering of sugarbeets complicates this problem. A typical weed management program may include a preplant incorporated herbicide or a preemergence herbicide at planting, an early postemergence herbicide, possibly a layby herbicide application, and one to several cultivations coupled with hand hoeing. The actual sequence of herbicides used in the program and the timing of the applications will vary by region, and by planting and harvest date.

Several herbicides are registered for selective weed control in sugarbeet, but no single chemical will control all weeds that infest beet fields. Frequently two or more herbicides may have to be combined sequentially or as tank mixes to achieve adequate broad-spectrum weed control. The weed species present will to a large degree determine the choice of herbicides in such combinations. The necessity for correct weed identification cannot be overemphasized. The best weed management program can only be devised when knowledge of the weed species present is coupled with the herbicide activity type and weed susceptibility to the herbicide.

Most sugarbeet herbicides are applied as bands centered on the crop row. Width of the band applied depends to a considerable degree on the capability to conduct close cultivation. Narrower herbicide bands can be utilized if close cultivation can be achieved. This has advantages in cost reduction and also places less herbicide into the

environment. It may be useful to increase the width of the band for herbicides used in late fall and winter plantings if cultivation is likely to be delayed because of wet soil conditions.

Poor or erratic weed control can occur with any herbicide used in sugarbeets. Unsatisfactory herbicide performance may be the result of several factors, such as poor land preparation, faulty herbicide timing and application, the presence of resistant weed species, wrong soil moisture conditions, or adverse weather before or after application. In addition, sugarbeet herbicides are not 100% selective and can, under certain conditions, cause stunting, death of leaf tissue (necrosis), or even kill sugarbeet seedlings. Some beet growth retardation can be tolerated provided the stand is not reduced, but it may lead to increased problems with seedling pests. Minimize herbicide injury to the crop as much as possible.

MONITORING

Ideally, sugarbeet fields should be monitored for weeds in the winter, spring, summer, and fall. If this is not feasible, monitor fields at least twice per year: in late winter to determine the cool season weed population and in late summer to determine the warm season weed population. While monitoring, it is particularly critical to note any weeds that have escaped control in the previous crop(s) and were able to set seed. Because seeds can remain viable in soil for years, monitoring done over a period of years, can provide the means to predict which species are likely to be present.

If no weed history is available for a field, take a soil sample from the field and germinate weed seeds to determine which species are present. It is critical to know this information before planting so that correct weed management decisions can be made, especially if postplant or preemergence herbicides are to be used.

WEED MANAGEMENT BEFORE PLANTING

Management of weeds in sugarbeets requires a combination of control strategies. Cultural, including rotation, and mechanical controls are considered the core of a weed management program. Reliance solely on herbicides for weed control is not sound management. Before planting a sugarbeet crop consider field selection, sanitation, crop rotation, land preparation, and preirrigation as they relate to weed management.

Field Selection

Choose fields known to be free of perennial weeds such as johnsongrass, field bindweed, and curly dock, annual weeds such as sunflower, cocklebur, velvetleaf, and wild beets, or other weeds that are difficult or impossible to control economically in the sugarbeet crop.

Strict adherence to plantback intervals is critical to follow because small amounts of selective herbicides used in a previous crop may remain (carryover) in the soil long enough to affect a sugarbeet crop planted the following season. Sugarbeets are very sensitive to substituted dinitroaniline herbicides such as trifluralin (Treflan) or pendimethalin (Prowl), which are used for weed control in cotton, safflower, beans, tomatoes, and alfalfa. Avoid planting sugarbeets in fields where these herbicides were used the previous year. Benefin (Balan) used in lettuce, napropamide (Devrinol) in tomatoes and peppers, or atrazine (Aatrex) in corn or sorghum may also carry over and injure sugarbeets if the interval between crops is too short. Do not plant sugarbeets in fields previously treated with halosulfuron (Sanda) for at least 36 months following treatment.

Sanitation

Many weeds and volunteer sugarbeets from previous crops may host diseases (e.g., beet yellows virus, curly top virus), insects (e.g., green peach aphid), and nematodes (e.g., sugarbeet cyst nematode), and thus act as sources of infestation for the sugarbeet crop. To reduce the risk of infestation, control weeds and escaped volunteer beets in or around sugarbeet fields. In addition, do not allow weeds to grow in irrigation ditches because seeds can float and be carried back onto the field.

Clean all field equipment before entering a field if the last field in which the equipment operated was weedy. Land planes and sugarbeet diggers have great potential to carry seeds, tubers, etc., from field to field. Prevention is often easier than controlling an established weed problem.

Rotation

Do not plant beets in the same field more than once every 4 or 5 years to minimize disease, nematode, and weed problems. Weeds are less troublesome if beets are planted following tilled row crops and are more troublesome following pasture, alfalfa, broadcast-planted safflower, sorghum, or any other crop in which weeds were allowed

to mature and set seed. Rotation allows reduction of weed populations that are difficult to control in sugarbeets, such as velvetleaf.

Land Preparation

Uniform beds with accurate row spacing are essential for precision cultivation and permit application of narrower bands of postemergence herbicides. The degree to which precision cultivation can be performed is established at the time of initial bed preparation.

A well-prepared seedbed that is free of large clods permits precision planting with more rapid and uniform emergence of beet seedlings. Uniform seeding depth is critical when using preplant incorporated herbicides as increased depth of seeding can result in increased phytotoxicity to the seedlings. Well-prepared seedbeds also permit proper and accurate incorporation of preplant incorporated herbicides, leading to improved weed control. Soil that is too finely cultivated, however, may crust and inhibit germination.

Preirrigation

Unless winter rains occurred, preirrigate before seedbed preparation. Preirrigation followed by cultivation improves the tilth of the seedbed and permits better mechanical incorporation of preplant herbicides. A preirrigation can also be applied following initial bed preparation if there is not enough rainfall to germinate weed or carryover crop seeds. Preirrigation is particularly useful following barley, wheat, oats, sorghum or safflower crops. After the weeds and volunteer seedlings emerge, shallowly cultivate the beds. Paraquat or glyphosate may be used in place of cultivation on preshaped beds. In sprinkler-irrigated fields where preemergence herbicides are used, preirrigation reduces the amount of water needed to germinate the crop. This can improve the activity and selectivity of herbicides because less water is needed and, thus, the herbicide is not leached too far into the soil.

Herbicides

Before the crop is planted, there are two major types of herbicides for weed control. The first group kills existing weeds that have emerged after the beds were formed; these herbicides are referred to as preplant foliar herbicides. The second group, preplant incorporated, controls weed seeds as they germinate. As the name implies, the latter herbicides must be incorporated into the soil soon after application to prevent volatilization of the chemical and to move the herbicide into the soil zone where weed seeds germinate.

Preplant foliar

Postemergence herbicides such as paraquat (Gramoxone Inteon) and glyphosate (Roundup) are used to kill existing weeds on preformed beds before planting sugarbeets. Paraquat has contact action only and is thus most effective on young seedlings. Be careful that the chemical does not drift off the target field. Glyphosate has systemic action and is thus effective on established weeds. A few species, such as mallows (*Malva* spp.) and nettles (*Urtica* spp.), are tolerant to this herbicide and are not well controlled by it.

Preplant Incorporated

Preplant incorporated herbicides perform best when incorporated with a power driven rotary tiller with L-shaped tines. Observe label directions regarding depth of incorporation as not all of these herbicides require the same depth. Incorporating herbicides like pyrazon (Pyramin), and ethofumesate (Nortron) too deeply dilutes them and decreases weed control. Too shallow incorporation of cycloate (Ro-Neet) results in poor weed control because of volatilization of the herbicide and lack of exposure of the seedling's underground shoot to the chemical. A 1- or 2-inch error in depth of incorporation can lead to substantial loss of performance. If beds have not been shaped accurately, precise depth of incorporation may not be possible and herbicide performance will be erratic. Preplant incorporation does not work well in cloddy soil and herbicide performance will usually be poor under such conditions. Excessive speed (over about 2 mph) with a power incorporator results in poor incorporation. The soil should be dry at incorporation in order to obtain optimum results.

Cycloate (Ro-Neet) must be incorporated immediately after application to reduce losses to volatility; this is particularly critical if the soil is moist. Disc incorporation of cycloate (Ro-Neet) can provide adequate control of grass weeds but often results in only partial control of broadleaved species; consequently, another herbicide is often required to obtain adequate broadleaf weed control. Disc incorporation also runs the risk of mixing the herbicide too deeply in the soil, thus increasing the risk of injury to the crop.

WEED MANAGEMENT AFTER PLANTING

Proper fertilization, irrigation, and insect and disease control measures promote good crop growth. A healthy, vigorous crop provides substantial competition that suppresses weed growth and acts as part of the weed control program. A healthy, vigorous beet is also better able to tolerate herbicides.

Crop Stand

Final beet stands should be uniform with skips not over 18 inches. Weed-free beets closer than 18 inches apart will compensate for such skips. A uniform stand will help to compete with weeds, but even with 12- to 18-inch gaps, weeds can invade and become established in the space that exists before the crop canopy fills in.

Biological Control

No specific systems of biological control have been introduced for control of weeds in the sugarbeet crop. Many weeds are attacked, however, by endemic insects and pathogens. Such attack weakens the weeds and makes them less competitive with the crop, and reduces seed production. Examples of insects that attack weeds include leafminers on purslane, fleabeetles on groundcherry and nightshade, various lepidopteran larvae on pigweed, and carabid beetles eating weed seeds. Pathogens attack johnsongrass, barnyardgrass, and purslane among others. Insect and disease control practices should be used so that they minimize impacts on organisms providing natural biological control of weeds.

Cultivation

Cultivation is an effective method of weed control, especially in fields with low weed infestations. It is essential that bed shaping and planting be accurate in order to permit close, or precision, cultivation. Repeated shallow cultivations will dislodge small weed seedlings that emerge after each irrigation and can be performed until the beet leaf canopy closes over the furrow.

Weed control by cultivation must be coordinated with irrigation scheduling. Wet soil can prevent the use of cultivation equipment at the optimum stages of weed growth. Timing of irrigation following cultivation can also be critical. Irrigation too soon after cultivation can lead to rerooting of weeds. Wet soil in winter may delay, or even preclude, cultivation for weed control; this possibility should be considered when designing a weed management program for fall-planted beets.

Many different types of cultivation implements are available. Each should be adjusted to disturb only a shallow layer (ideally not over 2 to 3 inches) of soil to minimize pruning of the beet roots and bringing weed seeds up from deeper layers. Timeliness in cultivation is essential. Seedling weeds are much easier to kill than older established weeds. Random or synchronous thinning also reduces weed populations. Some tools that aid in removing weed seedlings in beets older than the 4-leaf stage are the Bezzerides row weeder, the Texas rod weeder, and various spyder wheels.

Hand hoeing

Include hand hoeing as part of a long-term weed management program, especially when weeds such as wild beets, sunflower, velvetleaf, and tolgua, which are resistant to most of the currently registered herbicides, are present. Although hand hoeing is relatively expensive and has no long-term effect, it may be useful for situations where weeds have escaped control by other techniques or are too large to control with other methods. Hand hoeing is easiest when the weeds are small; large weeds are difficult to remove and their removal may damage the crop.

Herbicides

Following planting of the crop, there are three periods in which herbicides may need to be applied, depending on the weed species present. Preemergence treatments are applied after planting but before the first irrigation; postemergence treatments are applied when sugarbeets are in the seedling stage; and layby treatments may be useful after the crop has been thinned if continued emergence of weeds is anticipated.

Preemergence

Preemergence pyrazon (Pyramin) treatments are not effective unless incorporated by light rainfall or sprinkler irrigation (less than 0.5 inch). Apply less than 0.75 inch of sprinkler irrigation per set following preemergence application of pyrazon until the beets have four true leaves or the herbicide may be leached into the seedling root zone and cause injury to the crop. If significant rainfall occurs following treatment, the risk of crop injury is increased. Under furrow irrigation physical incorporation of the herbicide is required.

Postemergence

Inadequate control following postemergence applications of pyrazon (Pyramin) has occurred when weeds were beyond the 2- to 4-leaf stage, or when applied in warm weather (over 70°F) and not irrigated within 2 or 3 days. Irrigation following application is essential for best results because the herbicide must be moved into the weed root zone. The likelihood of crop injury increases in warm weather.

Phenmedipham plus desmedipham (Betamix) gives erratic control when applied to weeds larger than cotyledon to 2-leaf stage of growth. Poor weed control has occurred when weeds were stressed for moisture at application, and low soil moisture also increases injury to sugarbeets. Temperatures above about 85°F on application day may lead to increased injury to the beets. When temperatures are high, or rising, applications made in the morning cause more injury; spraying after 3 p.m. will reduce injury to the beets. Injury is also less if temperatures are decreasing.

Split applications about 7 to 12 days apart (shorter split in spring and summer, longer split in late fall and winter) with the first application to cotyledon stage beets and weeds. This usually increases weed control and reduces injury to sugarbeets; the first application must not exceed 0.5 lb/acre. If pigweed is the predominant broadleaf weed present, application of desmedipham (Betanex) will provide slightly greater control than phenmedipham plus desmedipham (Betamix). The combination of phenmedipham, desmedipham, and ethofumesate (as a tank mix of Betamix plus Norton or a premix of Progress) can improve control of difficult-to-control weeds such as common knotweed.

Sethoxydim (Poast) must be applied with an oil concentrate adjuvant to obtain satisfactory activity. Repeat applications if perennials such as johnsongrass are present. This herbicide should not be mixed with any other herbicide; mixtures with phenmedipham plus desmedipham (Betamix) have resulted in decreased grass control. Soil moisture must be adequate at application in order to obtain high levels of grass control; low soil moisture reduces control substantially. High spray volume leads to reduced activity; follow label restrictions in relation to spray volume.

Layby

Neither trifluralin (Treflan) or EPTC (Eptam) have any activity against established weeds; it is thus essential that the field be weed free prior to application of these herbicides. Both herbicides must be physically mixed into the soil (incorporated) immediately after application, or they must be applied in the irrigation water.

SPECIAL WEED PROBLEMS (11/05)

All broadleaf perennial weeds pose a difficult problem for sugarbeet production because all herbicides that control such perennials also kill sugarbeets. The best approach is to control the weeds in rotational crops and only plant sugarbeet if populations of the problem weed are low.

Several annual broadleaf weeds that grow in fall and winter are not well controlled by phenmedipham plus desmedipham (Betamix), including redmaids, miner's lettuce, dogfennel, and knotweed. It is necessary to use other herbicides to control these weeds.

VELVETLEAF

The most widespread problem weed in spring- and summer-sown beets is probably velvetleaf. Control this weed in rotational crops because the only herbicide registered for use in sugarbeets in California that will give more than partial control is triflurosulfuron methyl (UpBeet), which requires 2 sequential applications for control. Close cultivation and hand hoeing when velvetleaf is small provides control in sugarbeets. If velvetleaf has not yet become established in a field, a program that prevents seed production should be followed.

KNOTWEEDS AND SMARTWEEDS

These weeds can be a problem at times. Preemergence combinations of pyrazon (Pyramin) and ethofumesate (Nortron) early in the season can control them. Split applications of Progress or a tank-mix of Betamix plus Nortron has also provided high levels of control. Partial control of later emerging weeds can be anticipated from the Nortron.

DODDER

The parasitic plant dodder can invade sugarbeets. The majority of dodder emerges from the soil from mid-March through mid-May, so close monitoring during this period is essential. None of the registered herbicides for use in sugarbeets control this weed. It is probably best to kill the individual infested sugarbeet plants rather than let the weed set seed.

CEREALS

Volunteer cereals are best controlled with timely application of sethoxydim (Poast) when they are young. Otherwise, applying EPTC (Eptam) during the season via water run irrigation can provide preemergence control.

COCKLEBUR

Cocklebur is commonly associated with fields near rice fields and ditches where water can be used to move the seed. Cocklebur is only partially controlled with current preplant or preemergence herbicides. For effective control, apply clopyralid (Stinger) or split applications of triflurosulfuron methyl (UpBeet) plus Progress when weeds are no larger than the cotyledon stage. When using Progress plus UpBeet, it is critical that both applications be made at 5-10 day intervals or control will be significantly reduced.

CURLY DOCK

Postplant, preemergence treatment with ethofumesate (Nortron), pyrazon (Pyramin), or a combination of the two can give effective control of germinating weeds. Seedy plants can be controlled with combinations of Betamix plus Nortron, or the premix Progress, as split applications. Once well established, most herbicides are not effective and hand hoeing is required. Clopyralid (Stinger), however, can give partial control of established plants.

COMMON AND SCIENTIFIC NAMES OF WEEDS (11/05)

Common Name	Scientific Name
Barley, hare	<i>Hordeum murinum</i> subsp. <i>leporinum</i>
Barnyardgrass	<i>Echinochloa crus-galli</i>
Bluegrass, annual	<i>Poa annua</i>
Bromegrasses	<i>Bromus</i> spp.
Canarygrasses	<i>Phalaris</i> spp.
Chickweeds	<i>Stellaria</i> spp.
Clovers	<i>Trifolium</i> spp.
Cocklebur	<i>Xanthium</i> spp.
Crabgrass, large	<i>Digitaria sanguinalis</i>
Cudweeds	<i>Gnaphalium</i> spp.
Datura, sacred	<i>Datura wrightii</i>
Dock, curly	<i>Rumex</i> spp.
Fescues	<i>Festuca</i> spp.
Fiddlenecks	<i>Amsinckia</i> spp.
Filarees	<i>Erodium</i> spp.
Fleabane, hairy	<i>Conyza bonariensis</i>
Foxtails	<i>Setaria</i> sp.
Goosefoot, nettlefoot	<i>Chenopodium murale</i>
Groundcherries	<i>Physalis</i> spp.
Groundsels	<i>Senecio</i> spp.
Henbit	<i>Lamium amplexicaule</i>
Johnsongrass	<i>Sorghum halepense</i>
Knotweed, common	<i>Polygonum arenastrum</i>
Lambsquarters, common	<i>Chenopodium album</i>
Lettuce, prickly	<i>Lactuca serriola</i>
Lovegrass	<i>Eragrostis</i> spp.
Mallow, little (cheeseweed)	<i>Malva parviflora</i>
Marestail	<i>Hippuris vulgaris</i>
Miner's lettuce	<i>Claytonia perfoliata</i>
Mustards	<i>Brassica</i> spp.
Nettles	<i>Urtica</i> spp.
Nightshades	<i>Solanum</i> spp.
Nutsedges	<i>Cyperus</i> spp.
Oat, wild	<i>Avena fatua</i>
Orach, halberdleaf	<i>Atriplex triangularis</i>
Pigweeds	<i>Amaranthus</i> spp.
Pineapple-weed	<i>Chamomilla suaveolens</i>
Polypogon, rabbitfoot	<i>Polypogon monspeliensis</i>
Popcorn flower	<i>Plagiobothrys</i> spp.
Povertyweed, Nuttall	<i>Monolepis nuttalliana</i>
Puncturevine	<i>Tribulus terrestris</i>
Purslane, common	<i>Portulaca oleracea</i>
Radish, wild	<i>Raphanus raphanistrum</i>
Redmaids (desert rockpurslane)	<i>Calandrinia ciliata</i>
Rocket, London	<i>Sisymbrium irio</i>

(continued next page)

Common Name	Scientific Name
Ryegrasses	<i>Lolium</i> spp.
Sandburs	<i>Cenchrus</i> spp.
Shepherd's-purse	<i>Capsella bursa-pastoris</i>
Sowthistles	<i>Sonchus</i> spp.
Speedwells	<i>Veronica</i> spp.
Spurge, spotted	<i>Chamaesyce maculata</i>
Thistle, Russian	<i>Salsola tragus</i>
Velvetleaf	<i>Abutilon theophrasti</i>

SUSCEPTIBILITY OF SPRING AND SUMMER WEEDS IN SUGARBEET TO HERBICIDE CONTROL (1/10)

	Preplant Foliar		Preplant Incorporated or Postplant Preemergence				Postplant Postemergence									Layby				
	GLY	PAR*	CYC	ETH	PYR	ETH	DES	CLE	CLO	P/D	PYR	P/D	ETH	P/D ²	ETH	SET	TRS	EPT	PYR	TRI
ANNUAL WEEDS																				
Barnyardgrasses	C	P	C	P	N	P	N	C	N	N	N	P	C	C	P	C	N	C		
Cocklebur	C	C	N	N	P	P	P	N	C	P	P	P	P	N	C	N	N	N		
Crabgrass	C	C	C	P	N	P	N	C	N	N	N	P	C	C	N	C	N	C		
Cudweeds	C	N	P	P	C	C	C	N	C	C	P	C	C	N	N	C	P	N		
Datura, sacred	C	C	N	C	P	P	C	N	P	C	N	C	—	N	N	N	N	N		
Docks (seedling)	C	C	P	C	C	C	C	N	C	C	P	C	C	N	C	C	P	C		
Fleabane, hairy	C	C	C	P	C	C	C	N	P	C	P	C	P	N	N	C	P	N		
Foxtail	C	C	C	C	N	C	N	C	N	N	N	P	C	C	P	C	N	C		
Goosefoot	C	C	C	C	C	C	C	N	N	C	N	C	C	N	C	C	N	C		
Groundcherries	C	C	P	C	C	C	C	N	P	C	P	C	C	N	C	C	P	N		
Knotweed, common	C	C	P	P	P	C	P	N	N	P	P	C	P	N	C	C	P	P		
Lambsquarters	C	P	C	C	C	C	C	N	N	C	P	C	C	N	C	C	P	C		
Lettuce, prickly	C	C	C	C	C	C	C	N	C	C	P	C	C	N	N	C	P	N		
Lovegrasses	C	C	C	C	N	C	N	C	N	N	N	P	C	C	N	C	N	C		
Marestail	C	C	C	P	C	C	C	N	P	C	P	C	P	N	N	C	P	N		
Nightshades	C	C	C	C	C	C	C	N	P	C	P	C	C	N	C	C	P	C		
Orach, halberdleaf	C	C	C	C	C	C	C	N	—	C	P	C	—	N	—	C	P	C		
Pigweeds	C	C	C	C	P	C	C	N	N	C	P	C	P	N	C	C	P	C		
Puncturevine	C	C	P	C	P	C	P	N	N	P	N	P	P	N	P	P	P	C		
Purslane, common	C	C	C	C	C	C	P	N	N	C	N	C	C	N	P	C	N	C		
Sandburs	C	P	C	P	N	C	N	C	N	N	N	P	C	C	N	C	N	C		
Sowthistles	C	C	C	C	C	C	C	N	P	C	C	C	C	N	C	C	C	N		
Spurge, spotted	C	C	C	C	C	C	C	N	N	C	P	C	N	N	—	C	P	N		
Thistle, Russian	C	P	P	P	P	P	P	N	N	P	N	P	P	N	P	P	N	P		
Velvetleaf	P	P	N	N	N	N	—	N	C	N	N	N	N	N	C	N	N	N		
Volunteer cereals	C	C	N	C	N	C	N	C	N	N	N	P	C	P	N	P	N	N		
PERENNIAL WEEDS																				
Johnsongrass seed	C	C	C	P	N	C	N	C	N	N	N	P	P	C	N	C	N	C		
Johnsongrass rhizome	C	N	N	N	N	P	N	C	N	N	N	N	N	C	N	C	N	N		
Nutsedges	P	P	P	P	N	P	N	N	N	N	N	N	P	N	N	C	N	N		

C = control N = no control P = partial control — = no information

- | | |
|------------------------------|---|
| CLE = clethodim (Select Max) | PAR = paraquat* (Gramoxone) |
| CLO = clopyralid (Stinger) | PYR = pyrazon (Pyramin) |
| CYC = cycloate (RoNeet) | P/D = phenmedipham/desmedipham (Betamix) |
| DES = desmedipham (Betanex) | P/D ² = phenmedipham/desmedipham/ethofumesate (Progress) |
| EPT = EPTC (Eptam) | SET = sethoxydim (Poast) |
| ETH = ethofumesate (Norton) | TRI = trifluralin (Treflan) |
| GLY = glyphosate (Roundup) | TRS = triflurosulfuron methyl (UpBeet) |

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

HERBICIDE TREATMENT TABLE (1/13)

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following materials are listed in alphabetical order. When choosing a pesticide, consider information relating to environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

BEFORE PLANTING*Preplant foliar*

- | | | | | |
|----|--|-------------------------------------|--------------|----|
| A. | GLYPHOSATE
(Roundup, Touchdown)
WSSA MODE OF ACTION GROUP NUMBER ¹ : 9
COMMENTS: Apply to emerged annual weeds at least 3 days before sowing crop or before it emerges. Weeds should be less than 4 inches tall and vigorously growing. Observe label restrictions for application. Restricted entry interval (REI) for Roundup is 4 hours and for Touchdown 12 hours. | 0.5–1.0 lb a.i. | see comments | NA |
| B. | PARAQUAT*
(Gramoxone Inteon)
... PLUS ...
surfactant
WSSA MODE OF ACTION GROUP NUMBER ¹ : 22
COMMENTS: Apply to emerged annual weeds before sowing crop or before it emerges. Grasses after tillering not well controlled. Avoid drift from treated area. Flush all spray equipment directly after use; paraquat may be corrosive to aluminum. | 0.5–0.1 lb a.i.

8 oz/100 gal | 24 | NA |

Preplant incorporated

- | | | | | |
|----|---|-------------------------------------|--------------|-------------|
| A. | CYCLOATE
(Ro-Neet) 6E
WSSA MODE OF ACTION GROUP NUMBER ¹ : 8
COMMENTS: Incorporate into soil immediately after application; use of power driven tiller preferred. Use only in mineral soils; lower rate in sandy soil, higher rate in heavy soils. May slow beet germination and seedling growth. Make only 1 application/growing season. | 3–3.99 lb a.i. | 12 | NA |
| B. | ETHOFUMESATE
(Nortron) SC
WSSA MODE OF ACTION GROUP NUMBER ¹ : 8
COMMENTS: Incorporate 1 to 2 inches deep with power-driven tiller. Temporary stunting with leaf fusion may occur. | 1–2 lb a.i. | 12 | NA |
| C. | PYRAZON
(Pyramin) DF
WSSA MODE OF ACTION GROUP NUMBER ¹ : not available
COMMENTS: Also known as chloridazon. Incorporate 1-2 in. deep with power driven tiller. If no rain falls within 5-10 days, furrow irrigate to thoroughly wet bed top. Do not use in sands, loamy sands, muck, or peat soils. Use lower rate on low organic matter sandy loam soils. Do not sprinkler irrigate until beets have 2 true leaves. Pyrazon is prone to settling out in the spray tank, so agitate continuously to avoid uneven application. | 3–3.5 lb a.i. | 12 | 0 |
| D. | PYRAZON
(Pyramin) DF
... PLUS ...
ETHOFUMESATE
(Nortron)
WSSA MODE OF ACTION GROUP NUMBER ¹ : (not available) plus 8
COMMENTS: Incorporate 1-2 in. deep with power-driven tiller. If no rain falls within 5-10 days furrow irrigate to thoroughly wet bed top. Do not use in sands, loamy sands, muck, or peat soils. Use lower rate on low organic matter sandy loam soils. Do not sprinkler irrigate until beets have 2 true leaves. Temporary stunting and leaf fusion may occur. Pyrazon, also known as chloridazon, is prone to settling out in the spray tank; agitate continuously to avoid uneven application. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. | 2.99 lb a.i.

1.5–1.9 lb a.i. | 12

12 | 0

90 |

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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AFTER PLANTING

Preemergence (Herbicides applied after planting but before irrigation)

A.	ETHOFUMESATE (Nortron SC) WSSA MODE OF ACTION GROUP NUMBER ¹ : 8 COMMENTS: Temporary stunting with leaf fusion and twisting may occur.	1.125–3.75 lb a.i.	12	NA
B.	PYRAZON (Pyramin) DF WSSA MODE OF ACTION GROUP NUMBER ¹ : not available COMMENTS: Also known as chloridazon. If no rain falls within 5-10 days, sprinkler irrigate; do not use more than 0.75 in. of water per set until beets have 2 true leaves. If significant rainfall occurs after treatment, the risk of crop injury is increased. Do not use in sands, loamy sands, muck, or peat soils. Use lower rate on low organic matter sandy loam soils. Pyrazon is prone to settling out in the spray tank; agitate continuously to avoid uneven application.	3–3.5 lb a.i.	12	NA
C.	PYRAZON (Pyramin) DF ... PLUS ... ETHOFUMESATE (Nortron) SC WSSA MODE OF ACTION GROUP NUMBER ¹ : (not available) plus 8 COMMENTS: If no rain falls within 5 -10 days, sprinkler irrigate; do not use more than 0.75 in. of water per set until beets have 2 true leaves. Do not use in sands, loamy sands, muck, or peat soils. Use lower rate on low organic matter sandy loam soils. Temporary stunting, with leaf fusion and twisting, may occur. Pyrazon, also known as chloridazon, is prone to settling out in the spray tank so agitate continuously to avoid uneven application. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i.	2.99 lb a.i. 1.5–1.9 lb a.i.	12 12	0 90

Postemergence (seedling stages)

A.	CLETHODIM (Select Max) ... PLUS ... N/S SURFACTANT WSSA MODE OF ACTION GROUP NUMBER ¹ : 1 COMMENTS: Keep spray volume at 20-30 gpa for best activity. Adequate soil moisture required for best activity. Do not mix with other herbicides. Controls annual bluegrass when plants have fewer than 8 leaves. Perennial grasses may require repeat applications.	0.09–0.2425 lb a.i.	24	40
B.	CLOPYRALID (Stinger) WSSA MODE OF ACTION GROUP NUMBER ¹ : 4 COMMENTS: Apply when crop and weeds are at cotyledon stage of growth; delayed application can increase risk of crop injury. Effective for controlling velvetleaf and cocklebur. It can be tank-mixed with UpBeet, Betamix, or Progress for broader weed control. Do not exceed 0.25 lb/acre/season. Refer to label for significant plant-back restrictions.	0.1–0.2425 lb a.i.	12	45
C.	DESMEDIPHAM (Betanex) WSSA MODE OF ACTION GROUP NUMBER ¹ : 5 COMMENTS: Temporary sugarbeet stunting may occur, with possible sugarbeet kill at temperatures over 85°F. Adequate soil moisture must be present at application, or furrow irrigate after treatment. If pigweed is the primary species, desmedipham alone provides better control than in a mixture with phenmedipham. Does not have soil activity.	1.0–1.21875 lb a.i.	24	75
D.	PHENMEDIPHAM+DESMEDIPHAM (Betamix) WSSA MODE OF ACTION GROUP NUMBER ¹ : 5/5 COMMENTS: Temporary sugarbeet stunting may occur, with possible sugarbeet kill at temperatures over 85°F. Treat cotyledon-stage beets for best results. Control is erratic if weeds are larger than 2-leaf stage. Adequate soil moisture must be present at application, or furrow irrigate after treatment. Application after 3:00 pm increases safety to crop. Split applications about 7 days apart (50% of rate applied at each application) are safer and more effective than single applications. Do not exceed 0.5 lb/acre at the first application when applying to cotyledon-stage beets.	0.24–0.75 lb a.i.	24	75

UC IPM Pest Management Guidelines - SUGARBEET

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
E. PHENMEDIPHAM+DESMEDIPHAM (Betamix) ... PLUS ... ETHOFUMESATE (Nortron)	0.24 lb a.i. 0.125 lb a.i.	24 12	75 90
WSSA MODE OF ACTION GROUP NUMBER ¹ : 5/5/ plus 8 COMMENTS: Temporary sugarbeet stunting may occur, with possible sugarbeet kill at temperatures over 85°F. Treat cotyledon-stage beets for best results. Control is erratic if weeds are larger than 2-leaf stage. Adequate soil moisture must be present at application, or furrow irrigate after treatment. Application after 3:00 pm increases safety to crop. Split applications about 7 days apart (50% of rate applied at each application) are safer and more effective than single applications. Do not exceed 0.5 lb/acre at the first application when applying to cotyledon-stage beets. This mixture can provide improved control of difficult-to-control weeds such as knotweed. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i.			
F. PHENMEDIPHAM+DESMEDIPHAM+ ETHOFUMESATE (Progress)	0.25–0.75 lb a.i.	48	75
WSSA MODE OF ACTION GROUP NUMBER ¹ : 5/5/8 COMMENTS: A premixed herbicide applied as a split-sequential application 7 to 10 days apart, beginning at the crop and weed cotyledon stage. Can be tank-mixed with UpBeet and Stinger for broader weed control.			
G. PYRAZON (Pyramin) DF	2.99 lb a.i.	12	0
WSSA MODE OF ACTION GROUP NUMBER ¹ : not available COMMENTS: Also known as chloridazon. Use on small broadleaf weed seedlings in the 2- to 4-leaf stage during the cool season (below 70°F). If no rain falls, irrigate within 4 days to move the herbicide into the weed root zone. Controls certain weeds resistant to mixtures of phenmedipham/desmedipham. Pyrazon requires continuous agitation of the spray tank to prevent uneven application.			
H. SETHOXYDIM (Poast) ... PLUS ... COC adjuvant	0.25–0.45 lb a.i. 1 qt/acre	12	60
WSSA MODE OF ACTION GROUP NUMBER ¹ : 1 COMMENTS: Keep spray volume 20-30 gpa low for best activity. Adequate soil moisture required for best activity. Do not mix with other herbicides. High spray volume leads to reduced activity; follow label restrictions in relation to spray volume to use. Will not control annual bluegrass; perennial grasses may require repeat treatments.			
I. TRIFLUSULFURON METHYL (UpBeet) ... PLUS ... N/S SURFACTANT	0.016–0.031 lb a.i.	4	60
WSSA MODE OF ACTION GROUP NUMBER ¹ : 2 COMMENTS: Apply as a split-sequential application 5-10 days apart, beginning at the cotyledon stage of the crop and weeds. Two applications required in most cases for effective control. It may be tank-mixed with Betamix, Progress, or Stinger to broaden weed control. Do not mix with grass herbicides (Poast or Prism). Use with caution to prevent weed resistance following other ALS-inhibiting herbicides, such as Raptor, Staple, or Matrix.			

LAYBY (after thinning)

A. EPTC (Eptam)	2 lb a.i.	12	49
WSSA MODE OF ACTION GROUP NUMBER ¹ : 8 COMMENTS: Inject into irrigation water; use only where uniform irrigation can be achieved. Will not control emerged seedlings or established plants. Do not permit treated water to run off field or use it for irrigating other crops. Follow-up repeat application is required for best activity. ... or ... 3 lb a.i. COMMENTS: Must be thoroughly incorporated into soil.			

UC IPM Pest Management Guidelines - SUGARBEET

Common name (trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
B. TRIFLURALIN (Treflan) WSSA MODE OF ACTION GROUP NUMBER ¹ : 3 COMMENTS: Incorporate into soil immediately after application; use of ground-driven rolling cultivator is preferred. Avoid piling treated soil into the beet crowns. Field must be weed-free at treatment; does not control emerged weeds.	0.75 lb a.i.	12	NA

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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.

* 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. For more information, see <http://www.hracglobal.com>.

NA Not applicable.

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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.

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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FOR UNIVERSITY OF CALIFORNIA PUBLICATIONS REGARDING PROGRAM PRACTICES**

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