UC IPM
Pest Management Guidelines:
Corn

September 2011

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

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

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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM World Wide 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.

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Corn Year-Round IPM Program Annual Checklist (9/11)

Supplement to UC IPM Pest Management Guidelines: Corn

These practices are recommended for a monitoring-based IPM program that enhances pest control and reduces environmental quality problems related to pesticide use.

Water quality becomes impaired when pesticides and sediments move off-site and into water. Air quality becomes impaired when volatile organic compounds (VOCs) move into the atmosphere. Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this page for information on how to minimize water and air quality problems.

This year-round IPM program covers the major pests of field corn in the Central Valley. This program does not cover sweet corn. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Pest Management Guidelines. Track your progress through the year with this annual checklist form.

✓ Done	**Preplant activities** **Special issues of concern related to environmental quality: pesticide runoff and leaching.** Mitigate pesticide usage to minimize air and water contamination.
	Select the field: • Consider soil type, cropping and pest history, and plant back restrictions from previous crop. • Take soil samples for nutrient, salinity, and pH analysis to determine field suitability and soil nutrient management.
	Survey weeds when the previous crop is still in the field. • Keep records, noting the presence, location, and extent of problematic weeds. (See example form online.)
	Manage weeds according to the Corn Pest Management Guidelines. • Use winter flooding, where appropriate, in the Delta. • Pre-irrigate and cultivate to germinate and destroy weed seedlings.
	Consider crop rotation to prevent build up of soilborne pathogens, such as Fusarium and Pythium stalk rot, and problem weeds.
	Clean equipment and tractors between fields to prevent the spread of soilborne diseases and weed seeds.
	Prepare the field: • Manage residue from the previous crop and consider reduced tillage options. • Determine if planting flat or using beds. • If using beds, prepare seed beds with good drainage. • Apply fertilizer based on soil test results.
	In the San Joaquin Valley, choose planting dates considering a harvest by October 31 to help lower infestation rate of corn leafhopper and corn stunt.
	Select an appropriate hybrid based on yield and pest history. • Consider herbicide resistance and insect resistance. • Purchase only the genetic traits needed by understanding the stacked trait options.

✓Done	**Planting to 5th leaf** Mitigate pesticide usage to minimize air and water contamination.
	Consider a soil or seed treatment if wireworms have been a problem in the past or if conditions are conducive for seedcorn maggots. Avoid planting into overly wet or overly soft seedbeds.
	Soon after planting, monitor the field to identify germinated weeds. • Keep records. (See example form online.) • Manage weeds according to the Corn Pest Management Guidelines.
	If nutsedge, johnsongrass, or bermudagrass are present, cultivate with sweeps or knives before corn is 8 inches tall. If using glyphosate resistance technology, follow directions carefully and rotate with other herbicides and mechanical methods to avoid resistant weeds.
	Look for the following pests or their damage as corn emerges, and manage as needed according to the Corn Pest Management Guidelines. • Cutworms • Flea beetles • Seed corn maggot • Wireworms
	Other pests or damage you may see: • Aphids • Armyworms • Corn leafhopper • Corn leafminer • Cucumber beetles • Grasshoppers • Seed rots and damping-off • Thrips

✓Done	**6th leaf to tassle appearance** **Special issues of concern related to environmental quality: volatile organic compounds (VOCs), drift, runoff.** Mitigate pesticide usage to minimize air and water contamination.
	Survey and manage weeds. • Keep records. (See example form online.) • Manage according to the Corn Pest Management Guidelines. • Consider postemergent herbicides for weed seedlings not controlled by cultivation. ○ Create a custom herbicide chart for your field. Learn how.
	Randomly select and pick older, lower leaves on several corn plants throughout the field and inspect for spider mite damage. Manage as needed according to the Corn Pest Management Guidelines.
	Consider taking leaf tissue samples for nutrient analysis and apply nutrients as necessary.
	Monitor for Pythium stalk rot to prepare for next year's management.
	If aphids appear on the tassels, consider treating to prevent spreading of viruses.
	Look for corn leafhopper and note problems for next year's management.

	6th leaf to tassel appearance (continued)
	Other pests or damage you may see: • Armyworms • Corn leafminer • Cucumber beetles • Grasshoppers • Thrips

✓ Done	Early silk through maturity **Special issues of concern related to environmental quality: volatile organic compounds (VOCs), drift, runoff.** Mitigate pesticide usage to minimize air and water contamination.
	Monitor for diseases. If you find heavy infection rates of: • Charcoal rot—note for next season's management planning. • Fusarium stalk rot and Pythium stalk rot—consider crop rotation out of corn. • Fusarium ear rot, head smut or common smut–note for next year's variety choices.
	Other pests and damage you may see: • Armyworms • Cucumber beetles • Corn earworm
	If spider mite colonies are present, consider treating with Oberon at least 30 days before harvest.
	If more than ten percent of stalks have fallen over due to Pythium or Fusarium stalk rot, schedule an early harvest.
	Right before harvest, sample ears from different quadrants of the field. Check for damage to assess this year's pest management and to plan for next year. • No ears/poorly filled ears • Curved ears • Red leaves

✓ Done	Harvest and postharvest Mitigate pesticide usage to minimize air and water contamination.
	In the San Joaquin Valley, harvest grain and silage corn: • At the appropriate moisture level to prevent mold growth during storage. • By Oct. 31 to provide longest corn-free crop period possible for corn leafhopper.
	Disc under crop residue and volunteer corn to control seedcorn maggot, Fusarium stalk rot, Pythium stalk rot, corn leafhopper, and corn stunt.
	Plan next season's crop rotation.

✓ Done	Pesticide application checklist
	When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems. **Choose a pesticide from the UC IPM Pest Management Guidelines for the target pest considering:** ▪ Impact on natural enemies and honeybees [http://www.ipm.ucdavis.edu/PMG/r604900111.html]. ▪ Potential for water quality problems and impact on aquatic invertebrates using the UC IPM WaterTox database [http://www.ipm.ucdavis.edu/TOX/simplewatertox.html]. (See Pesticide Choice publication [http://anrcatalog.ucdavis.edu/pdf/8161.pdf] for impact on aquatic invertebrates.) ▪ Chemical mode of action if pesticide resistance is an issue. **Before an application:** ▪ Choose sprayers and application procedures that keep pesticides on target. ▪ Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site. ▪ Review and follow pesticide labeling for handling, storage, and disposal guidelines. ▪ Check and follow restricted entry intervals (REI) and preharvest intervals (PHI). **After an application:** ▪ Record application date, product used, rate, and location of application. ▪ Follow up to confirm that treatment was effective. ▪ Consider water management practices that reduce pesticide movement offsite: ▪ Install an irrigation recirculation or storage and reuse system (See Mitiating Pesticide Hazards: Irrigation Recirculation and Reuse http:/www.ipm.ucdavis.edu/mitigation/water_reuse.html.) ▪ Use drip rather than furrow irrigation. ▪ Limit irrigation to amount required using soil moisture monitoring. ▪ Consider vegetative filter strips http:/www.ipm.ucdavis.edu/mitigation/veg_filtering.html ▪ Install sediment traps. ▪ Use polyacrylamide (PAM) tablets in furrows to prevent offsite movement of sediments. ▪ Redesign inlets and outlets into tailwater ditches to reduce erosion. **Consider management practices that reduce air quality problems:** ▪ When possible, choose pesticides that are not emulsifiable concentrate (EC) formulations, which release volatile organic compounds (VOCs) http://www.ipm.ucdavis.edu/mitigation/reducing_voc.html. VOCs react with sunlight to form ozone, a major air pollutant. ▪ Use the Department of Pesticide Regulation calculators to determine VOC emission rates from fumigant and nonfumigant pesticides.

More information about topics mentioned on this checklist is available at the website: http://www.ipm.ucdavis.edu/PMG/selectnewpest.corn.html.

For more about mitigating the effects of pesticides, see http://www.ipm.ucdavis.edu/mitigation/.

General Information

RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN CORN TO NATURAL ENEMIES AND HONEY BEES (8/08)

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]
Bacillus thuringiensis ssp. *aizawaii*	11.B1	narrow (caterpillars)	L	L	L	IV	none
Bacillus thuringiensis ssp. *kurstaki*	11.B2	narrow (caterpillars)	L	L	L	IV	none
carbaryl (Sevin) 50, 80	1A	broad (insects, mites)	L/H	H	H	I	long
carbaryl (Sevin) XLR	1A	broad (insects, mites)	L	H	H	II	long
carbaryl (Sevin) XLR Plus	1A	broad (insects, mites)	L	H	L	III	long
carbaryl (Sevin) carbaryl bait	1A	—	L	L	L	IV	short
chlorpyrifos (Lorsban)	1B	broad (insects, mites)	M	H	H	I	moderate
clothianidin (Poncho)	4A	narrow (soil insects)	—	—	—	IV	—
dimethoate (Cygon)	1B	broad (insects, mites)	H	H	H	I	long
disulfoton (Di-Syston)	1B	broad (insect, mites)	H	H	H	III	—
endosulfan (Thiodan)	2A	broad (insects, mites)	L	M	M	III	short
esfenvalerate (Asana)	3	broad (insect, mites)	H	M	H	I	moderate
indoxacarb (Avaunt)	22	narrow (caterpillars)	—	L	L	I	moderate
malathion	1B	broad (insects, mites)	H	H	H	II	moderate
methomyl (Lannate)	1A	broad (insects, mites)	H	H	H	III	moderate
methoxyfenozide (Intrepid)	18A	narrow (caterpillars)	L	L	L	IV	none
permethrin (Ambush, Pounce)	3	broad (insects, mites)	L	H	H	I	long
petroleum oils	—	broad (exposed insects, mites)	L	L	L	III	short to none
propargite (Comite)	12C	narrow (pest mites)	M[7]	L	L	IV	short
spinetoram (Radiant)	5	narrow (caterpillars, thrips, aphids)	L	M[8]	L/M	III	moderate[9]
spinosad (Entrust, Success)	5	narrow (caterpillars, thrips, aphids)	L	M[8]	L/M	III	short to moderate[8]
spiromesifen (Oberon)	23	narrow (mites)	—	—	—	IV	
thiamethoxam (Cruiser)–seed trt.	4A	narrow (seedcorn maggot, wireworms)	—	—	—	NA	short to none

Continued on next page . . .

Relative Toxicities, continued

H = high M = moderate L = low — = no information NA = not applicable

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 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 additional information, see their Web site at http://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, toxicites are to western predatory mite, *Galendromus occidentalis*. Where differences have been measured, 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 Use lowest rates for best management of western predatory mite/spider mite ratio.

8 Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5-7 days after, especially for syrphid fly larvae.

9 Residual is moderate if solution is between pH of 7 to 8.

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

APHIDS (8/08)

Scientific Names: Corn leaf aphid: *Rhopalosiphum maidis*
Greenbug: *Schizaphis graminum*
Green peach aphid: *Myzus persicae*

DESCRIPTION OF THE PESTS

Several species of aphids may be found in corn, but corn leaf aphid and greenbug are the primary aphid species infesting corn in California. Corn leaf aphids are small to medium and bluish green in color and also infest small grains. The greenbug is a moderate-sized aphid. The color of the abdomen is light green with a darker stripe down the middle. Both winged and wingless forms of both aphids occur on corn plants.

DAMAGE

Corn leaf aphid infestations usually start in the plant whorl. Heavy infestations may curl leaves and stunt the plant. Later infestations may completely cover the tassels and upper leaves. Corn leaf aphids excrete a sticky substance called honeydew, which accumulates on the plants. The honeydew eventually turns blackish as sooty molds grow on it. Heavy amounts of sooty mold may be more damaging to silage corn than to corn for grain.

Greenbugs and green peach aphids also infest corn, but usually do not build up to the high numbers of corn leaf aphids. Red lesions often form at the feeding sites of greenbugs. High numbers of greenbugs on small plants can kill the plants. All three species transmit maize dwarf mosaic virus to corn from nearby sources. Johnsongrass is one of the common weed hosts for this virus.

MANAGEMENT

Transmission of virus disease is the primary damage caused by aphids and the potential for this varies significantly from year-to-year and area-to-area. Insecticide sprays will not prevent virus transmission, but can reduce population levels. There are no established thresholds for aphids on field corn. Only on rare occasions do aphids reach damaging populations. Obtaining good coverage of the plant, which is essential for effective control, can be difficult when the plants are 5 feet tall or more and treatments may increase problems with mites by killing natural enemies.

Biological Control

Aphids can be kept below economic levels of feeding damage by the parasite *Lysiphlebus testaceipes* and by predators such as lacewings, lady beetles, and syrphid flies. However, biological control cannot prevent transmission of virus diseases.

Organically Acceptable Methods

Biological control and oil and soap sprays are acceptable for use on organically grown crops.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.			
A. DIMETHOATE 400 MODE OF ACTION GROUP NUMBER[1]: 1B COMMENTS: For field corn only.	0.66–1 pt	48	Feed/graze: 14

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
B. ESFENVALERATE* (Asana XL)	5.8–9.6 fl oz	12	Seedcorn/Popcorn: 1 Field: 21
MODE OF ACTION GROUP NUMBER[1]: 3 COMMENTS: Do not exceed 0.25 lb a.i./acre/season on field corn and seed corn or 0.5 lb a.i./acre/season on popcorn. May cause mite outbreaks.			
C. ENDOSULFAN* (Thionex) 3EC	1.33 qt	17 days	1
MODE OF ACTION GROUP NUMBER[1]: 2A COMMENTS: For fresh sweet corn only. Do not exceed 2 qt/acre/year.			
D. CHLORPYRIFOS* (Lorsban) 4E	1–2 pt	24	Grain or ears: 21 Livestock feed: 35 Grazing or silage: 14
MODE OF ACTION GROUP NUMBER[1]: 1B COMMENTS: Not for use on popcorn. Avoid drift and tailwater runoff into surface waters.			
E. NARROW RANGE OILS#	Label rates	4	0
MODE OF ACTION: Contact including smothering and barrier effect.			

** Mix with sufficient water to obtain full coverage.

\+ 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.

\# 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 additional information, see their Web site at http://www.irac-online.org/.

ARMYWORMS (8/08)

Scientific Names: Armyworm: *Pseudaletia unipuncta*
Beet armyworm: *Spodoptera exigua*
Western yellowstriped armyworm: *Spodoptera praefica*

DESCRIPTION OF THE PESTS

Eggs of the armyworm and beet armyworm are pale green to pink, striated, and deposited in a mass that is covered with a white cottony material. At first, the tiny, newly hatched larvae feed in a colony, skeletonizing the first few leaves on which they feed. The larvae are about 1.25 inches long when full grown. Armyworms are greenish brown in color with several longitudinal stripes, while beet armyworm are mottled olive green to almost black.

Eggs of the western yellowstriped armyworm are similar to those of the beet armyworm. The egg masses are larger and covered by a gray cottony material. Newly hatched larvae also feed in colonies; mature larvae attain a length of 1.5 to 2.0 inches and are black with a prominent yellowish stripe and several narrow bright ones on each side of the body. An intense black spot is usually visible on each side of the first legless segment behind the head.

DAMAGE

Newly hatched armyworms feed in colonies and skeletonize leaves. Larvae that are half grown or more will feed singly on leaves, in the ear, or on the tassels. Damage by armyworm to the ears resembles that caused by corn earworm. Because of the damage to tassels and ears, tolerance for armyworm damage in sweet corn is very low.

MANAGEMENT

Armyworms are often attracted to fields with barnyardgrass. When they are done feeding on barnyardgrass, larvae move to corn so it is important to control this weed. Specific treatment thresholds have not been established for armyworms on field corn, but treatment is seldom necessary. Sweet corn, however, has a greater potential for damage and may require treatment. While these pests may be present any time from June through September, populations are usually most damaging in late summer. For sweet corn, pheromone traps may be useful to determine the timing of moth flights and subsequent larval infestations. In those rare instances where control measures are required, the beet armyworm is more difficult to control than the western yellowstriped armyworm and may require the higher treatment rate of the materials recommended below. Insecticide applications will be most effective if applied against small larvae. Frequently, spot treatments are sufficient.

Organically Acceptable Methods

Controlling weeds, especially barnyardgrass, and applying sprays of *Bacillus thuringiensis* are organically acceptable management tools.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

A. INDOXACARB
(Avaunt) 2.5–3.5 oz 12 Sweet corn: 3
Fodder/stover: 35

MODE OF ACTION GROUP NUMBER[1]: 22
COMMENTS: For use on sweet corn only. Can only be used before silking. Do not apply more than 14 oz product/acre/crop and allow at least 3 days between sprays.

B. METHOXYFENOZIDE
(Intrepid) 2F 4–8 oz 4 Field: 21
Sweet corn: 3 (ears/forage)
21 (dry fodder)

MODE OF ACTION GROUP NUMBER[1]: 18A

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
C. METHOMYL*			
(Lannate SP)	0.25–0.5 lb	48	see label
MODE OF ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not apply more than 2.25 lb a.i./acre/crop for field and popcorn, and 6.3 lb a.i./acre/crop for sweet corn. Phytotoxicity may occur on certain sweet corn varieties.			
D. BACILLUS THURINGIENSIS ssp. AIZAWAI#			
(various products)	Label rates	4	0
MODE OF ACTION GROUP NUMBER[1]: 11.B1			
COMMENTS: This material may be less effective than broad-spectrum insecticides, but it does not destroy natural enemies of corn earworm. Control is maximized by thorough coverage and by making applications when larvae are small.			
E. SPINETORAM			
(Radiant) SC	3–6 fl oz	4	see comments
MODE OF ACTION GROUP NUMBER[1]: 5			
COMMENTS: For control of beet armyworms and armyworms; not for western yellowstriped armyworm. Preharvest interval for sweet corn and seed corn harvested for grain is 1 day and 3 days when harvested for forage and fodder; for field corn, teosinte, and popcorn it is 28 days for grain harvest and 3 days for forage and fodder.			
F. ESFENVALERATE*			Seed corn/Popcorn: 1
(Asana XL)	5.8–9.6 fl oz	12	Field: 21
MODE OF ACTION GROUP NUMBER[1]: 3			
COMMENTS: Do not exceed 0.25 lb a.i./acre/season on field corn and seed corn or 0.5 lb a.i./acre/season on popcorn.			
G. PERMETHRIN*			Grain or fodder: 30
(Pounce) 3.2EC	4–8 oz	12	Sweet corn: 1
MODE OF ACTION GROUP NUMBER[1]: 3			
COMMENTS: For field corn, popcorn, field corn grown for seed, and sweet corn. Apply before brown silk stage.			

** Mix with sufficient water to obtain full coverage.

\+ 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.

\# Acceptable for use on organically grown produce.

[1] Modes of action are important in preventing the development of resistance to pesticides. 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. 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 is assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/

CORN EARWORM (8/08)

Scientific Name: *Helicoverpa zea*

DESCRIPTION OF THE PEST

Corn earworm moths are most active during evening and night. They are about 0.75 inch long, rather robust, with a wing span of 1 to 1.5 inches, and adults range from olive green, to tan, to dark reddish brown in color. Egg laying occurs throughout the sweet corn growing season. The tiny, white eggs are laid singly on the foliage and fresh corn silk, which is the favorite site for egg deposition. After about a day, eggs develop a reddish brown ring in the top portion. Eggs are spherical with 12 or more ridges radiating from the top. Young larvae are greenish with black heads and conspicuous black hairs on the body. Fully developed worms are about 1.5 inches long and range in color from pale green or pinkish to brown.

DAMAGE

The corn earworm may be present throughout the season but is most abundant during August and September. Larvae feed on leaves, tassels, the whorl, and within ears, but the ears are the preferred sites for corn earworm attack. Ear damage is characterized by extensive excrement at the ear tip. Young larvae feed on corn silks, clipping them off. Shortly thereafter, they feed their way into the ear where they remain, feeding in the tip area until they exit to pupate in the soil.

MANAGEMENT

Corn earworm is primarily a problem in sweet corn where treatments should be timed to coincide with egg hatch.

Biological Control

Many predators and parasites attack corn earworm eggs, including several species of *Trichogramma*. Most parasitized eggs turn black, but there may be a lag period before they do so. General predators such as lacewings, minute pirate bugs, and damsel bugs feed on corn earworm eggs and small larvae.

Cultural Control

In sweet corn, very early plantings require fewer treatments than late-season corn because earworm population densities increase as the season progresses.

Organically Acceptable Methods

Biological and cultural controls and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable for use on an organically grown crop.

Monitoring and Treatment Decisions

Insecticidal control of corn earworm is difficult and depends on proper timing and thorough coverage. Begin sampling soon after corn emergence but pay particular attention to corn that is silking in late summer/early fall. The presence of large numbers of eggs on fresh corn silks indicates the potential for damaging populations. Eggs hatch in 5 to 7 days following oviposition. Once larvae enter the corn ears, control with insecticides is difficult. Direct insecticidal control towards young larvae that are feeding on the exposed ear tips. Treatments are usually not needed on field or silage corn. In sweet corn, where tolerance for worm damage is low, timing of insecticide treatments is critical: begin treatments during silking stage, at the start of egg hatch. Apply additional treatments if they are necessary.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

A. SPINOSAD

(Entrust)#	1–2 oz	4	Sweet, popcorn, seed: 1 - grain; 7 - forage
(Success)	3–6 fl oz	4	Field corn: 7 - forage; 2 8 - grain, fodder

MODE OF ACTION GROUP NUMBER[1]: 5
COMMENTS: Apply as a broadcast or as a directed spray with adequate spray volume and pressure to ensure thorough wetting of silk.

B. SPINETORAM

(Radiant) SC	3–6 fl oz	4	see comments

MODE OF ACTION GROUP NUMBER[1]: 5
COMMENTS: Preharvest interval for sweet corn and seed corn harvested for grain is 1 day and 3 days when harvested for forage and fodder; for field corn, teosinte, and popcorn it is 28 days for grain harvest and 3 days for forage and fodder.

C. METHOMYL*

(Lannate SP)	0.25–0.5 lb	48	see label

MODE OF ACTION: A carbamate (Group 1A)[1] insecticide.
COMMENTS: Certain varieties of sweet corn may be injured by methomyl.

D. ESFENVALERATE*

(Asana XL)	5.8–9.6 fl oz	12	Seed corn/Popcorn: 1 Field corn: 21

MODE OF ACTION GROUP NUMBER[1]: 3
COMMENTS: Do not exceed 0.25 lb a.i./acre/season on field corn and seed corn or 0.5 lb a.i./acre/season on popcorn.

E. PERMETHRIN*

			Grain or fodder: 30
(Pounce) 3.2EC	4–8 oz	12	Sweet corn: 1

MODE OF ACTION GROUP NUMBER[1]: 3
COMMENTS: For field corn, popcorn, and field corn grown for seed and sweet corn. Apply before brown silk stage.

F. CHLORPYRIFOS*

			Grain or ears: 21
(Lorsban) 4E	1.5–2 pt	24	Grazing or silage: 14 Livestock feed: 35

MODE OF ACTION: An organophosphate (Group 1B)[1] insecticide.
COMMENTS: For field corn and sweet corn (including corn grown for seed); not for use on popcorn. Apply as a broadcast spray. Avoid drift and tailwater runoff into surface waters.

G. BACILLUS THURINGIENSIS ssp. KURSTAKI#

(various products)	Label rates	4	0

MODE OF ACTION GROUP NUMBER[1]: 11.B2
COMMENTS: This material may be less effective than broad-spectrum insecticides, but it does not destroy natural enemies of corn earworm. Control is maximized by thorough coverage and by making applications when larvae are small.

** Mix with sufficient water to obtain full coverage.

\+ 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.

\# 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 additional information, see their Web site at http://www.irac-online.org/.

CORN LEAFHOPPER (1/06)

Scientific Name: *Dalbulus maidis*

DESCRIPTION OF THE PEST

The adult corn leafhopper is light tan in color and about 1/8 of an inch long. Its most distinguishing feature is two dark spots located between the eyes, which are visible using a 10X hand lens. The nymphs have no wings and are green to tan in color. They run rapidly across the under surface of the leaf when disturbed and may move from side to side and even backwards. Both adults and nymphs like to feed inside the whorl, particularly in young corn. Later, as the plants grow, they move out onto the underside of the leaves.

Corn leafhoppers overwinter as adults in the southern San Joaquin Valley. They prefer areas where they can find shelter such as grassy vegetation along waterways, ditch banks, and fence lines. Alfalfa fields are also a preferred overwintering site. The adults do not feed on alfalfa; they simply take up residence in the crowns where they spend the winter. As temperatures warm in spring, adult leafhoppers become active and fly around searching for corn. As soon as corn emerges, the adults move from their overwintering sites into the newly planted fields.

DAMAGE

Corn leafhopper causes damage in two ways. First, leafhoppers directly feed on the plant, sucking out juices. Heavy populations can cause the leaves to dry; also, both the adults and nymphs produce sticky honeydew while they feed, which gets on the corn leaves. Black sooty mold frequently grows on the honeydew, reducing the photosynthetic capacity of the plant. Secondly, and more importantly, the leafhoppers transmit a pathogen called *Spiroplasma kunkelii,* a bacteria-like organism that causes the disease corn stunt. Corn stunt is much more debilitating to the plants than the direct feeding damage caused by the leafhopper. The pathogen responsible for corn stunt overwinters within the adult leafhopper, so leafhoppers emerging from overwintering in early spring can be infective, as can later generations. Corn stunt causes plants to be stunted and can cause significant yield losses. For more information on this disease, see the section on corn stunt.

Until recently corn leafhopper was only a problem on late-planted corn (planted after July 1). Over the past few years, however, it has become a serious pest on early-planted corn as well, so leafhoppers may be found on corn as early as March and April. Corn leafhoppers damage silage corn, grain corn, and sweet corn.

DISTRIBUTION

In the Central Valley, the corn leafhopper has been identified from Kern, Kings, Tulare, Fresno, Madera, Merced, Stanislaus, San Joaquin, Sacramento, Solano, and Yolo counties. It has also been reported from Riverside and Los Angles counties. Corn stunt disease has been identified in Kern, Kings, Tulare and Fresno counties. The spiroplasma that causes the disease has been isolated from leafhoppers collected in Sacramento County, but the corn stunt disease has not yet been found.

MANAGEMENT

Early planting and maintaining a corn-free period over the winter months are key strategies in avoiding damage from the corn leafhopper and the incidence of corn stunt disease. In sweet corn, the use of reflective mulches may be a feasible management option. Chemicals are not effective at reducing the spread of the corn stunt spiroplasma by the leafhopper.

Biological Control

While a parasite has been reported from Mexico and South America, it has not been found in California. Large populations of minute pirate bugs, green lacewings, and assassin bugs are found associated with corn leafhopper populations, however, these common predators appear to have little effect on leafhopper populations.

Cultural Control

Leafhopper infestations and corn stunt disease become more severe as the growing season progresses. Planting as early as possible may help to lower the infestation rate of both, however, it will not eliminate the problem. Reflective plastic mulch has been shown to repel the adult leafhoppers and reduce

the incidence of corn stunt disease in sweet corn. While this strategy is too expensive for use in silage or grain corn fields, it may be practical for sweet corn production. Growers are urged to control volunteer corn plants that emerge following harvest. This includes volunteer corn in alfalfa fields and in winter forage crops planted after corn harvest. The volunteer corn plants are often present until killed by frost. In mild winters, these plants may survive the entire winter, and live adults and nymphs can be found deep within the whorl. Because corn is the only host for the corn leafhopper in California, these volunteer plants provide a winter host for the leafhopper and the spiroplasma, allowing them to survive. It is highly recommended that all corn be harvested no later than October 31 to provide the longest corn-free period possible.

In no-till systems, when corn is planted as a double crop following wheat or barley, the straw mulch has been shown experimentally to reduce the incidence of both the corn leafhopper and corn stunt disease. Additional research is needed, however, before this strategy can be proposed as a general management tool.

Organically Acceptable Methods
Planting over reflective mulch for management in sweet corn as well as the other management strategies listed under Cultural Controls are acceptable for use in organically certified corn.

Treatment Decisions
Treatment thresholds have not been established and insecticide treatments are not recommended. It is important to remember when dealing with a disease vector, that threshold values would be extremely low. A single, infected vector may inoculate many plants during its lifetime. While there are insecticides registered to control corn leafhopper on corn, they are not effective in preventing the incidence of corn stunt disease. Seed treatments with systemic insecticides have been shown to reduce corn leafhopper populations, but incidence of corn stunt disease has only been negligibly reduced. Reinfestations occur rapidly, particularly when other fields of corn in the area are being harvested, and leafhoppers are searching for other corn plants.

CORN LEAFMINER (1/06)

Scientific name: *Agromyza* sp.

DESCRIPTION OF THE PEST

The corn leafminer is the larva of a small black fly. The adult fly is seldom seen because of its small size and nondescript nature. Female flies lay eggs on the leaf surface. The eggs hatch into larvae that are tiny legless maggots, pale green to yellowish in color with a dark mouth hooks. The larva can be seen at the leading edge of the transparent "window" of the leaf mine. Leafminers are generally restricted to the lower leaves, up to the sixth leaf, on the plant. The upper leaves, those above leaf 7, have a much thicker cuticle and are less prone to injury.

At maturity, larvae drop from the leaves and pupate in the soil. The number of generations per year in California is not known, but there are probably at least five each season. The corn leafminer overwinters in the pupal stage in the soil.

Currently, corn leafminer appears to be restricted to the southern San Joaquin Valley. It is not present in either the high or low desert and there are no reports of it from the Sacramento Valley.

DAMAGE

In California, like most of the U. S., leafminers cause little or no economic damage in corn. After hatching, the larvae burrow into the leaves where they tunnel between the upper and lower leaf surface. Larvae feed on the mesophyll, leaving behind transparent tunnels or mines. As the maggots grow the mines increase in size, and the larvae form blotchy mines rather than the more familiar serpentine mines commonly observed on vegetables. (The parallel venation of the corn leaves prevents the development of serpentine mines.)

MANAGEMENT

The corn leafminer is not considered a pest, and no management practices are recommended for its control. One consideration to keep in mind, however, is the increasing practice of planting corn after corn, which could result in greater problems with this insect. Because the corn leafminer overwinters in the soil, the practice of planting corn after corn can lead to an increase in corn leafminer populations and attacks earlier in the season. Insecticides are not effective for leafminer maggots because the maggots are protected inside the leaf.

CUCUMBER BEETLES (1/06)

Scientific Names: Western spotted cucumber beetle: *Diabrotica undecimpunctata undecimpunctata*
Western striped cucumber beetle: *Acalymma trivittatum*
Banded cucumber beetle: *Diabrotica balteata*
Spotted cucumber beetle: *Diabrotica undecimpunctata howardi*

DESCRIPTION OF THE PESTS

The western spotted cucumber beetle and the western striped cucumber beetle occur throughout California. The other two species occur primarily in southern California. Cucumber beetles (also called corn rootworm beetles) overwinter as adults and are active beginning in early spring. Adults lay eggs at the base of plants. As soon as they hatch, larvae begin to feed on plant roots. They complete their development in the soil. There are about three generations a year.

Cucumber beetles are about 0.36 inch (1 cm) long and either have a greenish yellow background with black spots or alternating black and yellow stripes. They fly readily and migrate into cultivated areas from alfalfa and other crops and from uncultivated lands.

DAMAGE

Cucumber beetles feed on corn leaves, tassels, and silks. Damage is usually minimal. In some situations, larvae may cause serious injury by feeding on roots, and young plants can be killed or stunted.

MANAGEMENT

Cucumber beetles are attacked by a variety of natural enemies, the most important being a parasitic tachinid fly, *Celatoria diabroticae*. Treatment is rarely required to control cucumber beetles.

CUTWORMS (8/08)

Scientific Names: Black cutworm: *Agrotis ipsilon*,
Variegated cutworm: *Peridroma saucia*, and others

DESCRIPTION OF THE PESTS

Adults are moths approximately 1 inch long with a wing span of 1.25 to 2 inches and vary widely in coloration. Eggs are somewhat flattened on top, white to dull or off-white in color, and ribbed. They are generally deposited in massed rows. Eggs may be deposited on crop foliage, but are frequently found on weeds. Fully grown larvae range from 1 to 1.75 inches in length and commonly curl into a C-shape when disturbed.

Cutworms are most active and cause the most damage during spring and early summer months. The larvae normally hide under debris on the soil surface during the day, but are active, voracious feeders at night. Some cutworms climb into the host plant to feed, but many stay on the ground, cutting seedling host plants off at or just below the soil surface.

DAMAGE

Cutworms cut young plants off at the base or near the ground level. Usually, it is necessary to dig in the soil to find cutworm larvae and to determine the extent of the infestation and the size of the cutworms involved.

MANAGEMENT

If the cutworm population is reducing the plant stand, treat during the seedling stage. Frequently, the damage is most serious at the edges of a field, but stand loss can occur in a spotty pattern throughout the field. Treatment of hot spots may be possible. Seedlings will regrow if damage is above the growing point.

Organically Acceptable Methods

Eliminating weeds 2 weeks before planting both within and adjacent to the field can help to minimize cutworm problems in an organically managed crop.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

A. PERMETHRIN*
(Ambush) 25W — 6.4–12.8 fl oz — 12 — 1
MODE OF ACTION GROUP NUMBER[1]: 3
COMMENTS: Apply as a foliar application before brown silk stage.

B. CHLORPYRIFOS*
(Lorsban) 4E — 1–2 pt — 12 — Grain or ears: 21; Livestock feed: 35; Grazing or silage: 14
MODE OF ACTION GROUP NUMBER[1]: 1B
COMMENTS: Not for use on popcorn. Avoid drift and tailwater runoff into surface waters. Do not apply more than 6 pt/acre/season. Do not make more than 3 applications/season.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
C. CARBARYL			
(Sevin) 5% Bait	40 lb	12	see label

MODE OF ACTION: A carbamate (Group 1A)[1] insecticide.
COMMENTS: Ground or air application. Use only fresh bait. Apply in late afternoon or early evening so bait stays fresh longer. Avoid direct application to lakes, streams, ponds. Do not apply when weather conditions favor drift from treated areas. Do not contaminate water, food, or feed when cleaning equipment or disposing of wastes.

** Mix with sufficient water to obtain full coverage.

+ 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 additional information, see their Web site at http://www.irac-online.org/.

FLEA BEETLES (8/08)

Scientific Names: Desert corn flea beetle: *Chaetocnema ectypa*
Potato flea beetle: *Epitrix cucumeris*
Threespotted flea beetle: *Disonycha triangularis*
Palestriped flea beetle: *Systena blanda*

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 desert corn flea beetle is 0.125 inch long and brownish with two pale yellowish stripes along the wings. All of the flea beetles have enlarged hind legs and jump vigorously when disturbed, thus the name flea beetle.

DAMAGE

Damage is caused by adults. Feeding by the potato, palestriped, and threespotted flea beetles consists of numerous small rounded or irregular holes eaten in leaves so that leaves appear to have been peppered with small shot. Feeding by the desert corn flea beetle causes yellowish white feeding scars about 0.125 to 0.5 inches long along the leaf veins. In young plants particularly, the feeding damage can be very serious and can result in death. In addition to adult damage, larvae of the palestriped flea beetle feeds on roots of young plants as well as on germinating seeds.

MANAGEMENT

No economic thresholds are available but treatments, especially on young plants, should be considered if damage reaches a moderate level. Keep fields weed-free, particularly of field bindweed and mustard, which are preferred hosts of flea beetles. Heavily damaged fields should be replanted.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.			
A. CARBARYL* (Sevin) XLR Plus, 4F	1–1.5 qt	12	Sweet corn: 2 Forage: 14 Grain or fodder: 48
MODE OF ACTION GROUP NUMBER[1]: 1A			

** Mix with sufficient water to obtain full coverage.

\+ 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.

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GRASSHOPPERS (8/08)

Scientific Name: *Melanoplus* spp.

DESCRIPTION OF THE PESTS

Grasshoppers can be occasional pests of corn. In late summer and fall, grasshopper eggs are laid in grassy foothills, on ditchbanks, along roadsides and fence rows, in pasture areas, and in alfalfa fields. Eggs hatch in spring and young nymphs feed on nearby plants. When wild grasses and other plants become dry, grasshoppers migrate to irrigated croplands.

DAMAGE

Grasshoppers feed on foliage, most often on the edges of fields near pasture areas or roadsides. They seldom cause economically significant injury.

MANAGEMENT

Topical treatments are most effective; treating field borders may be adequate.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.			
A. CARBARYL* (Sevin) 80S, XLR Plus	10–24 oz	12	Sweet corn: 2 Forage: 14 Grain or fodder: 48
MODE OF ACTION GROUP NUMBER[1]: 1A COMMENTS: Ground or air application.			
B. MALATHION 8E	1 pt	12	Harvest or forage: 5
MODE OF ACTION GROUP NUMBER[1]: 1B COMMENTS: Limited residual effectiveness.			

** Mix with sufficient water to obtain full coverage.

\+ 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 additional information, see their Web site at http://www.irac-online.org/.

SEEDCORN MAGGOT (8/08)

Scientific Name: *Delia platura*

DESCRIPTION OF THE PEST

The seedcorn maggot adult is a slender, light gray fly, about 0.2 inch long; it is less robust appearing than the housefly. The whitish eggs are slightly curved with their posterior bluntly rounded. Mature larvae range from 0.2 to 0.25 inch in length, are white to whitish yellow, cylindrical, and taper anteriorly. Pupae are small brown capsules. In California, the seedcorn maggot is abundant primarily in spring, during or following a wet cycle, and is most common in fields containing a high amount of residue from a previous crop or where manure has been spread.

DAMAGE

Seedcorn maggots burrow into corn seeds and prevent germination. Slow emergence and poor stand establishment are signs of seedcorn maggot activity. Where slow, spotty emergence is observed, dig up seeds and inspect for maggot feeding. Soil and weather conditions such as cool soil temperature and periods of excessive moisture favoring slow seed germination and seedling emergence increase susceptibility to seedcorn maggot infestation.

MANAGEMENT

A preventive treatment (seed or broadcast) is the best method of control. To reduce attractiveness of a field to egg-laying adults, disc or plow early in the season, incorporating residues from a previous crop and destroying weed growth. Plant under ideal soil and weather conditions to assure rapid seed germination and minimize the seedcorn maggot problem.

Organically Acceptable Methods

Discing to incorporate crop residues and destroy weed growth and planting under ideal conditions are the best way to manage this pest in an organically certified crop.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

BEFORE PLANTING

A. THIAMETHOXAM
(Cruiser) 5FS — 0 / 12
MODE OF ACTION GROUP NUMBER[1]: 4A
COMMENTS: A seed treatment. Use allowed under a supplemental label. Do not apply other neonicotinoid (Group 4A) insecticides within 45 days of planting seed treated with this product.

B. CLOTHIANIDIN
(Poncho) — 0
MODE OF ACTION GROUP NUMBER[1]: 4A
COMMENTS: A seed treatment. Do not apply other neonicotinoid (Group 4A) insecticides within 45 days of planting seed treated with this product.

** Mix with sufficient water to obtain full coverage.

\+ 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.

[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 additional information, see their Web site at http://www.irac-online.org/.

SPIDER MITES (8/08)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*
Banks grass mite: *Oligonychus pratensis*
Strawberry spider mite: *Tetranychus turkestani*
Pacific spider mite: *Tetranychus pacificus*

DESCRIPTION OF THE PESTS

Mite infestations on corn frequently include a mixture of spider mite species, including twospotted spider mite, Banks grass mite, Pacific spider mite, and strawberry spider mite. Of these mite species, twospotted spider mite and Pacific spider mite are most common. Adult mites are about 0.06 inch in length, have four pairs of legs, are greenish to pink or cream colored, and have various sized black spots on the body. Under warm conditions spider mites move rapidly within the colony area. Spider mites have four stages of development: (1) the spherical, somewhat translucent egg; (2) a six-legged translucent larval stage; (3) an eight-legged nymphal stage; and (4) the eight-legged adult stage. A resting or quiescent stage occurs at the end of the larval and nymphal stages. A generation may pass in as few as 5 to 7 days in midsummer, or in a month during cool periods.

DAMAGE

All active stages of spider mites damage corn by removing juices from infested leaves, causing premature drying that results in loss of leaf tissue, stalk breakage, and kernel shrinking. Damaged leaves become somewhat yellowish and stippled on the upper surface and grayish due to webbing on the undersurface. Spider mites can be a serious problem on corn, particularly silage and sweet corn.

MANAGEMENT

Keep spider mite populations in check by reducing dust and weed hosts and encouraging mite predators. If monitoring indicates a need, treatment may be necessary on mid-size corn.

Biological Control

Spider mite populations may be held at very low levels by a number of predatory insects and mites, particularly early in the season. Thrips are effective early season predators, feeding primarily on spider mite eggs. Spider mites provide an important food source for predators such as minute pirate bugs and bigeyed bugs. Minimizing early season insecticide applications, which may reduce populations of beneficials, will reduce spider mite outbreaks. Naturally occurring predatory mites exert some level of control. In some areas, releases of predatory mites have been used to manage spider mites in field corn. If predatory mites are to be released, be sure to release the appropriate predatory mite species for the area and time of year. Also use the correct release rate and the correct timing. Definitive guidelines have not been developed, but make releases before significant spider mite outbreaks occur.

Cultural Control

Reduce spider mite problems by keeping fields, field margins, and irrigation ditches clean of weed hosts. Spider mite populations may increase more rapidly in areas where dust deposits are heavy on corn leaves. Thus, reducing dust may reduce the spider mite problem.

Organically Acceptable Methods

Biological controls and cultural controls are acceptable to use in organically grown crops.

Monitoring

Infestations usually begin on the lower portions of the plants and move upward as mite numbers increase. Evaluating spider mite infestations is most efficient if randomly selected, older, lower leaves are picked and inspected for stippling on the upper surface and webbing, mites, and feeding scars on the lower surface. Spider mite infestations that reach the ear leaf are most damaging.

Treatment Decisions

If small colonies of spider mites are found on the lower leaves of young plants throughout the field, control may be cost effective. Treat when corn is 2 to 4 feet tall; applications made after the plants exceed 4 feet in height usually result in poor control because good coverage is difficult to obtain. Just treating a couple of swaths around the field can keep spider mites from spreading into the remainder of the field.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

A. SPIROMESIFEN
(Oberon) 2SC — 5.7–8.5 f1 oz — 12 — 5 – green forage/silage; 30 – grain/stover

MODE OF ACTION GROUP NUMBER[1]: 23
COMMENTS: For use on field corn. See label for plant intervals. Do not make more than 2 applications/crop

B. PROPARGITE
(Comite) 6.55 lb/gal EC — 2–3 pt — 7 days — 30
MODE OF ACTION GROUP NUMBER[1]: 12C
COMMENTS: Apply to dry corn leaves. Apply before corn is 2–4 feet tall to ensure coverage. Tank mixing with oils and foliar fertilizers can result in injury.

** Mix with sufficient water to obtain full coverage.

\+ 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 additional information, see their Web site at http://www.irac-online.org/.

THRIPS (1/06)

Scientific Names: *Frankliniella occidentalis*, *Frankliniella williamsi*, and others

DESCRIPTION OF THE PEST

Thrips are small insects, about 0.04 inch long. Adult thrips have two pairs of narrow wings which are fringed with hairs. Immature thrips are wingless, whitish to yellowish in color, and are most commonly found in whorls, tassels, ears, or on the underside of leaves. Adults emerge continuously throughout the warm months. Adults and immatures may be found in corn at any time during the growing season. Eggs are deposited in plant tissue and hatching occurs in about 5 days during the summer months; the immature stages take about 5 to 7 days to complete development.

DAMAGE

Thrips are most noticeable and of greatest concern at two periods during the corn growing season: on young seedling plants and at ear formation. On young seedlings their feeding makes the plants look stunted. A common sign of a heavy thrips infestation is distorted leaves that turn brownish around the edges and cup upward. Usually the plants will grow away from the problem, just as they outgrow severe ragging resulting from wind damage. At ear formation, thrips and thrips injury to developing kernels provides entry for infection by *Fusarium* spp. and subsequent Fusarium ear rot diseases. The actual thrips injury does little damage; however, the ear rot diseases can be devastating.

Foliage-feeding thrips are effective predators on early-season spider mite infestations. Both adult and immature thrips may be found in spider mite colonies feeding on spider mite eggs.

MANAGEMENT

Treatment is usually not necessary on seedlings because plants recover from thrips injury. Thrips are also beneficial at this time because of their role as mite predators. No threshold has been established for damage from thrips at ear formation. Treating for thrips will probably not prevent spread of Fusarium ear rot diseases.

Biological Control

Minute pirate bugs (*Orius tristicolor*) play a major role in controlling thrips populations.

Cultural Control

Thrips populations tend to build up on weeds. Cultivating nearby weedy areas before corn emerges will reduce the potential of a thrips problem when the weeds begin to dry out. Cultivating weedy areas after corn emergence will increase thrips problems.

Organically Acceptable Methods

Good field sanitation and the preservation of beneficial insects will help to manage thrips in an organically grown crop.

WIREWORMS (8/08)

Scientific Name: *Limonius* spp. and others

DESCRIPTION OF THE PESTS

Wireworms are the soil-dwelling larvae of click beetles. They resemble mealworms and are slender, elongate, yellowish to brown with smooth, tough skin. The body is usually cylindrical, but flat on the lower side. There are six short legs close together near the head, and the tip of the abdomen bears a flattened plate with a pair of short hooks.

Wireworms may remain in the soil as larvae from 1 to 3 or more years, depending upon the species and the food supply.

DAMAGE

Wireworms feed on seeds and root portions of a wide variety of plants. In corn they can destroy germinating seeds and tiny seedlings. Often the wireworm will be found near the damaged or missing seed or plant. Wireworms will also attack young plants, resulting in weakened plants or a reduced stand. Damage is most likely to occur where corn is planted into a field formerly in pasture or weedy alfalfa.

MANAGEMENT

If wireworms have been a serious problem in the past, a preventive seed treatment or a treatment at planting may be necessary.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact.

A. THIAMETHOXAM
(Cruiser) 5FS — 12 — NA
MODE OF ACTION GROUP NUMBER[1]: 4A
COMMENTS: Use allowed under a supplemental label. Do not apply other neonicotinoid (Group 4A) insecticides within 45 days of planting seed treated with this product. May provide only partial control under high population pressure.

B. CLOTHIANIDIN
(Poncho) — 0 — NA
MODE OF ACTION GROUP NUMBER[1]: 4A
COMMENTS: A seed treatment. Do not apply other neonicotinoid (Group 4A) insecticides within 45 days of planting seed treated with this product.

C. CHLORPYRIFOS
(Lorsban) 15G — 8 oz/1000 row ft — 24 — Grain or ears: 21; Livestock feed: 35; Grazing or silage: 14
MODE OF ACTION GROUP NUMBER[1]: 1B
COMMENTS: Apply in-furrow or as a T-band application. The 8 oz rate provides suppression only unless used with a hopper box insecticidal seed treatment.

** Mix with sufficient water to obtain full coverage.

\+ 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 Modes of action are important in preventing the development of resistance to pesticides. 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. 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 is assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.

NA Not applicable.

Diseases

BACTERIAL SOFT ROT (8/08)

Pathogen: *Erwinia (Pectobacterium)* spp.

SYMPTOMS

Bacterial soft rot first appears as rapid desiccation of youngest leaves. A soft, watery rot of leaf tissue occurs inside the leaf whorl. The rot, which has an unpleasant odor, may kill the growing point of the plant.

COMMENTSON THE DISEASE

The disease is most commonly encountered in sprinkler-irrigated fields or when unseasonal rains occur. The bacteria are probably soilborne, and are carried into the whorl on soil particles. The mode of entry of the bacteria into the plant tissue is not clearly understood. It has been suggested that certain insecticides damage tissue inside the leaf whorl.

MANAGEMENT

Generally, no management of this disease is practiced. If soft rot develops, avoid sprinkler irrigation.

CHARCOAL ROT (1/06)

Pathogen: *Macrophomina phaseolini*

SYMPTOMS

Charcoal rot first becomes noticeable when corn is in the tassel stage or later. Infected stalks become shredded; the pith is completely rotted, leaving stringy vascular strands more or less intact. Small, black, spherical sclerotia of the fungus are found on and in the vascular strands; they are numerous enough to give the internal stalk tissue a gray color. As plants mature, the fungus grows into the lower internodes of the stalk, causing the plants to ripen prematurely and weakening the stalks, which may cause them to break.

COMMENTS ON THE DISEASE

The pathogen overwinters and is disseminated as sclerotia. Plants are infected through roots only after being predisposed by water stress. The fungus is favored by high temperatures.

MANAGEMENT

Good water management to avoid stressing plants is important in managing this disease, particularly as the crop approaches the flowering stage. Crop rotation to nonhost crops, such as small grains, can also help reduce the disease potential. There are no registered fungicides to control charcoal rot.

COMMON RUST (1/06)

Pathogen: *Puccinia sorghi*

SYMPTOMS

Common rust causes pustules that may appear on any aboveground part of the corn plant but they are most abundant on leaves. The pustules, which may erupt and become powdery, occur nearly simultaneously on both leaf surfaces. They are golden brown to cinnamon brown, becoming black as the spores mature.

COMMENTS ON THE DISEASE

Mild temperatures (60° to 73°F) and high relative humidity (near 100%) favor rust development. Initial inoculum is probably windblown spores from subtropical and tropical areas where the pathogen persists on living corn plants. The alternate host of the fungus, *Oxalis* species, probably does not play an important role in the disease cycle in California.

MANAGEMENT

Cultural Control

Use resistant hybrids to prevent common rust. Generally, fungicides are not required under California conditions.

COMMON SMUT (Boil Smut) (1/06)

Pathogen: *Ustilago maydis*

SYMPTOMS

Common smut is easily recognized by the tumorlike galls that form on any aboveground plant part. The conspicuous galls that replace kernels are covered with a greenish-white papery tissue. As the galls mature, the interior darkens and turns into masses of powdery, dark olive-brown to black spores. Ear galls may reach several inches in diameter. Galls that form on other plant parts, including the tassels and leaves, are much smaller.

COMMENTS ON THE DISEASE

Spores overwinter in the soil. Under favorable conditions these form secondary spores that are carried by air currents or splashed by water to young, developing corn tissues. Development of common smut is favored by dry conditions and temperatures between 78° to 93°F. The incidence of smut is higher in soils high in nitrogen or after heavy applications of manure. Injury to the plant tissue of any kind increases the potential for smut infection.

MANAGEMENT

Although no corn variety is immune, some hybrids and varieties are more resistant than others. Ask your local farm advisor for varieties that perform well in your area. Avoid mechanical injuries to plants and maintain well-balanced soil fertility. Rotate to another crop, the longer the better.

CORN STUNT (1/06)

Pathogen: *Spiroplasma kunkelii*

SYMPTOMS

Corn stunt, as the name implies, results in stunted plants. Severely infected plants and those infected early in their development may be only 5 feet tall with very short internodes, rather than the usual 10-12 feet in height. The stalk may have multiple ears, sometimes as many as 6-7 on a single plant. The ears are small and do not fill properly leaving a large number of blank spaces on the ear. The kernels that do develop are frequently "loose" leading to what is called "loose tooth ears". Younger leaves near the top of the plant are yellow. With age they take on a reddish to reddish-purple color that varies by variety.

COMMENTS ON THE CAUSAL AGENT

Spiroplasma kunkelii is a bacterial-like organism knows as a spiroplasma. Corn leafhoppers, *Dalbulus maidis*, carry the spiroplasma from diseased corn to healthy corn. The spiroplasma overwinters within the adult leafhopper; when the leafhoppers emerge from overwintering in early spring, they can be infective. Disease symptoms appear about 3 weeks after the corn is infected. The disease is most severe in corn planted after July 1 but can occur in corn planted as early as March and April.

COMMENTS ON THE DISEASE

All current commercial varieties of field and sweet corn appear to be susceptible. Yield loss depends on the growth stage of the corn when it is infected but can be significant, especially in late corn. Until recently, the occurrence of both the leafhopper and corn stunt were sporadic in the southern San Joaquin Valley. Since 1996, however, the leafhopper and corn stunt disease have occurred on a yearly basis with significant losses each year.

MANAGEMENT

Early planting is the best way to minimize damage from this disease. There is no chemical treatment to control the spiroplasma, and chemical treatment for the controlling the leafhoppers is generally not effective in controlling the disease.

EXSEROHILUM ROOT ROT (1/06)

Pathogen: *Exserohilum pedicellatum*

SYMPTOMS

Exserohilum root rot causes brown lesions on primary roots and later on secondary roots of the first and second whorls. The affected roots become black and necrotic. Aboveground symptoms include wilting, stunting, and yellowing of leaves, but these symptoms are not always apparent.

COMMENTS ON THE DISEASE

The fungus is soilborne. Although factors influencing disease development are not well understood, stress caused by a fertility imbalance, overcrowding, etc. may favor disease development.

MANAGEMENT

Good cultural practices will help to prevent this disease. There are no registered fungicides available for this disease.

FUSARIUM EAR ROT (8/08)

Pathogen: *Fusarium verticillioides*

SYMPTOMS

Fusarium ear rot results in white to salmon-pink discoloration of individual kernels or groups of kernels scattered over the ear. A white to pinkish weft of mycelia covers the kernels, especially on the tip of the ear. In severe infections the ears may be completely consumed by the fungus, leaving light-weight husks cemented to the kernels by mycelia.

COMMENTS ON THE DISEASE

Fungus growth is often associated with damage of the kernels caused by the feeding activity of insects. Although feeding damage by the corn earworm is readily apparent, it is the unseen damage caused by thrips that is indirectly responsible for most of the losses to ear rot in California. Thrips gain access to the kernels through the silk channel opening soon after pollination. The fungus is found on all corn tissue, but causes few problems unless tissue is damaged. Ear rot is most common in the Delta and in the Sacramento Valley.

MANAGEMENT

Use hybrids that have been thoroughly tested for ear rot resistance. Resistance is found in those hybrids with long husks that tightly enclose the silk channel opening of the ears. Husks that prevent or delay entrance of insects are responsible, in part, for resistance to ear rot. Early plantings usually escape serious injury. There are no registered fungicides for this disease.

FUSARIUM STALK ROT (1/06)

Pathogen: *Fusarium verticillioides*

SYMPTOMS

Corn plants with Fusarium stalk rot exhibit rotting of the roots, plant base, and lower internodes. The rot normally begins soon after pollination and becomes more severe as the plant matures. The lower stem becomes soft and eventually collapses. The pith inside the stems becomes tan to pink and disintegrates, leaving the vascular strands intact.

COMMENTS ON THE DISEASE

The fungus is ubiquitous in a corn field and colonizes the surfaces of all corn tissue but does no damage until the plants are near maturity. Stress and injury to plants seem to favor infection. This is the most common stalk rot in California.

MANAGEMENT

Optimal cultural practices (balanced fertility, good water management, crop rotation, plowing crop residues under, etc.) will help to prevent this disease. Some hybrids are more resistant than others. There are no registered fungicides for this disease.

HEAD SMUT (1/06)

Pathogen: *Sphacelotheca reiliana*

SYMPTOMS

Head smut is characterized by large smut galls that replace ears or tassels. The galls are first covered by fragile, creamy white membranes that eventually rupture to release masses of dark brown spores. Within the masses of spores are more or less intact threadlike strands of vascular bundles, giving the spore masses a stringy appearance. The vascular bundles within the galls readily differentiate head smut from common smut. In head smut, leaflike proliferations often occur in tassels and partially smutted ears.

COMMENTS ON THE DISEASE

Spores survive in the soil for long periods (at least several years). The fungus attacks seedlings and the mycelium becomes systemic in apical primordial tissue, invading undifferentiated floral tissues. Ideal conditions for growth are the same as those that favor germination and growth of the corn. Infection level is related to the concentration of spores in the soil. Although the spores may be seedborne, this is not an important source of inoculum. Spores may also be carried in the air during winds, but they drop to the ground and it is there that they germinate and infect the corn.

MANAGEMENT

Use resistant hybrids; most U.S. hybrids are tolerant. Check with your county farm advisors for the best ones to grow in your area. Fungicides are not available for head smut.

MAIZE DWARF MOSAIC (1/06)

Pathogen: Maize dwarf mosaic virus

SYMPTOMS

Symptoms of maize dwarf mosaic include narrow, light green to yellow streaks along the veins of leaves, leaf sheaths, and husks. As infected plants continue to grow and the temperature rises, the mosaic symptoms may disappear while the young leaves become more yellow. Plants may be stunted and have numerous tillers and poor seed set. Infected plants may be predisposed to ear rot and stalk rot.

COMMENTS ON THE DISEASE

Maize dwarf mosaic virus includes several strains that were once grouped in the sugarcane mosaic virus complex. One of the principal strains in corn in California is maize dwarf mosaic virus, strain A. The virus is transmitted by many species of aphids, including the corn leaf aphid (*Rhopalosiphum maidis*), the greenbug *(Schizaphis graminum*), and the green peach aphid (*Myzus persicae*). Although many grasses are infected by this strain of the virus, the principal overwintering reservoir host is johnsongrass. Most outbreaks of maize dwarf mosaic in corn can be traced to nearby johnsongrass.

MANAGEMENT

Use resistant hybrids to prevent the development of this disease. Eliminating johnsongrass within a quarter of a mile around the cornfield may effectively reduce disease incidence. Delay planting until aphid flights are over.

PYTHIUM STALK ROT (1/06)

Pathogens: *Pythium aphanidermatum* and other *Pythium* species

SYMPTOMS

Pythium stalk rot commonly becomes apparent when the plant suddenly falls over. Infection usually involves a single internode near the soil line. Diseased areas are dark brown, water-soaked, soft, and collapsed. The stalks may be twisted and distorted. Infected plants remain green and turgid for a short time after collapse because the vascular bundles remain intact.

COMMENTS ON THE DISEASE

Pythium stalk rot usually becomes evident shortly before or after the corn has tassled, although young, vigorous plants can be attacked. The disease is most often found in low spots in fields or in areas with poor drainage.

MANAGEMENT

Eliminate low areas in the field and improve drainage to prevent development of stalk rot.

SEED ROTS and DAMPING-OFF (8/08)

Pathogens: *Pythium* spp., *Fusarium* spp., *Penicillium oxalicum*, and other fungi

SYMPTOMS

Seed rot causes the corn seed to rot before germination and damping off causes the seedling to die soon after emergence. Infected tissue may be water-soaked (*Pythium*), white to pink (*Fusarium*), or bluish (*Penicillium*). The stem of infected seedlings becomes brown and soft near the soil line. Aboveground symptoms include yellowing, wilting, and death of the leaves.

COMMENTS ON THE DISEASE

Seeds or seedlings may be predisposed to disease by several factors, including planting depth, soil temperature, soil type, seed quality, and mechanical injury to the seed pericarp. These diseases are more common in poorly drained, excessively compacted, or cold (less than 55°F), wet soils. Sweet corn, especially the supersweet hybrids, is much more susceptible than dent (field) corn.

MANAGEMENT

Use high quality seed and good cultural practices, such as planting seed in warm soil (above 55°F), proper seedbed preparation, optimum water management, etc. Sweet corn, especially the supersweet hybrids, may benefit from fungicide seed dressings, especially in poorly drained and cold soils. Seed treatments for field corn are usually not warranted.

Common name (trade name)	Amount/Acre**	R.E.I.+ (hours)
SEED TREATMENTS		
A. CAPTAN 400	Label rates	0
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M4)		
COMMENTS: For sweet corn.		
B. THIRAM 50W	Label rates	24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)		
COMMENTS: For sweet corn, add mefenoxam (Apron XL LS).		
C. METALAXYL (Apron) XL	Label rates	0
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)		
COMMENTS: For super sweet corn.		

** Apply with enough water to provide complete coverage.

\+ 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.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info.

Weeds

INTEGRATED WEED MANAGEMENT (7/09)

Weeds compete with corn for light, nutrients, and water, especially during the first 3 to 5 weeks following emergence of the crop. It is important to control weeds in a corn field before they are 6 to 8 inches high, which is when they begin to impact corn yields. Late-season weed infestations do not reduce corn yield nearly as much as early weed competition; however, weeds at this time can harbor destructive insect pests such as thrips, which can vector Fusarium ear rot, and armyworms, which can defoliate corn. Weeds also reduce silage feed quality, slow harvesters by causing wheel slippage or clogging, raise grain moisture content, and provide a seed source to infest subsequent crops.

There are over 500,000 acres of corn throughout the state of which 70% is for silage and the rest for grain, with the exception of scattered plantings of sweet corn, ornamental corn, and popcorn. The acreage grown for grain is very price dependent and is usually loca ted in the general proximity of large dairies.

No single weed control regime is effective for all growing conditions. An integrated weed management program utilizes a combination of cultural, mechanical, and chemical methods for consistent, effective weed control. It also helps prevent the development of weed resistance to herbicides and the emergence of a few dominant weeds. A vigorous, competitive crop produced through proper seedbed preparation, variety selection, seeding rates, fertilization, irrigation, cultivation, pest control, and crop rotation is the best defense against weed infestations and competition.

Transgenic Corn. Herbicide-tolerant varieties of corn are being grown in California and provide additional options for weed control. Most transgenic corn being grown is developed by the insertion of genes that transfer tolerance for glyphosate (Roundup), which expands the control options for annual and perennial grass and broadleaf weeds.

Monitoring
To properly manage weeds in corn, survey and identify weeds in the field to be planted to corn while the previous crop is still in the field. Soon after planting, examine the corn field to identify germinated weeds. Make counts as you walk through the field to get a realistic picture of the weed species present, their growth stage, and density. UC ANR Publication 3488, *Weeds of California and Other Western States*, is a good pictorial reference to assist in identifying weeds as is the weed gallery of photos available online at http://www.ipm.ucdavis.edu/PMG/weeds_intro.html.

Cultural Control
Cultural practices play an important role in corn weed management. In California a well-managed corn crop is extremely competitive with most weeds. Good cultural practices including timely cultivations often control weeds sufficiently to maximize yields and profit. Keeping fence lines, ditches, and wasteland areas free of weeds will reduce sources of infestation. It is especially important to thoroughly clean tillage equipment and harvesters before entering or leaving a field to prevent spread of weeds from one field to another.

Cultivation is also important in corn weed management because it serves to cut or mechanically bury weeds in the seedling stage before they have a change to become well established and compete with corn or produce seed. It also serves as a tool for weed resistance management.

Growing corn under no-till or reduced tillage also reduces weeds because the soil is not disturbed, thus reducing the number of seeds that germinate. For weeds that do emerge, postemergent herbicides can be applied.

HERBICIDES
Herbicides are important where weed populations are high, with difficult-to-control weeds, or where it is critical to gain time because cultivation equipment is being used elsewhere. Herbicides reduce the early competition of weed infestation, reduce the seed bank, and reduce the potential for competition in the following crop. Preplant, preemergent, or postemergent herbicides are available that will selectively

control most species of weeds in corn. Select an herbicide based on costs, weeds present, stage of corn growth, soil type, succeeding rotation crop, and adjacent crops.

WEED MANAGEMENT BEFORE PLANTING

Several measures can be taken to reduce weed infestations before the crop is planted, beginning with the selection of a relatively weed-free field. Preparing the seedbed so that it is free of large soil clods provides favorable conditions for corn seed germination and early growth, as well as improved performance of preplant herbicides. The selection of a vigorous growing variety on 30-inch row spacing will help the crop compete with weeds. Uniform plant population densities of 30,000 to 34,000 plants per acre maintain yields and reduce mid- to late-season weed growth by maximizing shading.

Preirrigation or rainfall before planting corn can be useful to germinate weed seeds that can subsequently be controlled by cultivation or postemergent herbicides such as glyphosate, paraquat, or carfentrazone (Shark). Weed sweeps are excellent tools for cultivating johnsongrass, nutsedge, and bermudagrass.

Preplant, preemergent herbicides are applied to the soil surface and mechanically mixed in the soil before the crop is planted. Herbicides applied before the corn emerges offer the advantage of controlling weeds before they compete with the corn when it is in the seedling stage; this is the most critical time in regard to yield reduction. Preplant herbicides such as EPTC (Eradicane), alachlor (Micro-Tech), or metolachlor (Dual Magnum) can be applied broadcast on flat ground and incorporated by discing before beds are formed and the corn is planted, or they can be applied in a band on preformed beds, then incorporated with a rolling cultivator or power tillers.

To maximize the performance of preplant incorporated herbicides, the following are important:

- Preirrigate where feasible.
- Disc in manures before incorporating the herbicide.
- Incorporate to the proper depth: 4 to 6 inches for EPTC and 2 to 3 inches for alachlor or metolachlor. When applying herbicides to beds with a rotary hoe, incorporate two times, once each in opposite directions. Broadcast applications of EPTC require cross-discing for maximum incorporation and effective weed control.
- Time incorporation according to label: EPTC immediately; alachlor and metolachlor, 7 to 14 hours.
- Chop up perennials such as johnsongrass or bermudagrass by cross-discing or mulching before planting.
- Use proper incorporation speed.
- Disturb nutsedge by using sweeps or power mulchers before planting.
- Plant immediately after herbicide application.
- Time the first irrigation to enhance herbicide activity.

WEED MANAGEMENT AFTER PLANTING

After the crop emerges, cultivating with rolling cultivators or sweeps can significantly reduce weeds between the rows, but weeds in the crop row may require further control. Corn plants that are 8 inches or higher have roots that extend well into the furrow. Rolling cultivators cause less root pruning than sweeps or knives, but are less effective on nutsedge, johnsongrass, and bermudagrass. Root pruning can be minimized by staying at least 4 inches from the corn and throwing soil to the plant. (Be careful not to throw hot, sandy soil against tender stalks.)

Weeds not controlled by cultivation can be controlled with a postemergent herbicide application, depending on the weed species present and its growth stage. Postemergent herbicides are most effective when applied to weed seedlings. An over-the-top application can be used but some products or tank mixes require a directed spray on corn larger than 8 to 12 inches in height to keep the herbicide out of the whorl and to minimize the risk of corn injury. Postemergent herbicides commonly used in corn include 2,4-D, bromoxynil (Buctril), carfentrazone (Shark), dicamba (Banvel, Clarity), dicamba/halsulfuron (Yukon), diflufenzopyr (Distinct), halosulfuron (Sandea), metribuzin (Sencor), nicosulfuron (Accent), and foramsulfuron (Option). It is important, however to pay close attention to application guidelines on the labels to avoid phytoxicity to the crop, especially with carfentrazone (Shark).

SPECIAL WEED PROBLEMS (7/09)

BARNYARDGRASS AND VOLUNTEER CEREALS. These weeds are especially a problem in fields not preirrigated. Barnyardgrass is one of the most common weeds in California corn. High populations of this weed can occur in fields in continuous corn or those irrigated up. A high population of barnyardgrass may attract an infestation of armyworms, which moves from the weed to feed on corn leaves.

Preplant incorporated herbicide options for the control of barnyardgrass include s-metolachlor (Dual Magnum), alachlor (Micro-Tech), and EPTC (Eradicane).

In certain areas and soil types, pendimethalin (Prowl) can be applied to prevent any further germination of barnyardgrass seeds following the last cultivation for weeds. Thoroughly and uniformly incorporate pendimethalin into the soil with a sweep type or rolling cultivator set to incorporate in the top 1 inch of soil, and irrigate beds to thorough wetness.

The most effective postemergent treatment for control of barnyardgrass is to apply nicosulfuron (Accent) for control up to 3 inches in height or foramsulfuron (Option) for control up to 4 inches. A competitive corn crop and cultivation will improve control.

In a Roundup Ready tolerant crop, glyphosate can be applied over-the-top until the V8 stage for grass control. Barnyardgrass can be difficult to control, however, if it is drought stressed.

NUTSEDGE. Nutsedge is very competitive with corn in the early stages of growth. Running a sweep 4 inches below the top of the bed or power tilling the beds with L-shaped knives 3 to 4 inches deep before planting is effective in inhibiting nutsedge that has already sprouted. It is important to cultivate a second time for nutsedge after the crop has emerged. In the second cultivation, throw soil to the corn plants to help suppress nutsedge growth and allow corn growth to shade the furrow.

S-metolachlor (Dual Magnum) and alachlor (Micro-Tech) herbicides can give effective preemergent yellow nutsedge control. EPTC (Eradicane) controls both yellow and purple nutsedge. Use the highest label rates for your soil type for the most effective control.

Postemergent applications with halsulfuron (Sandea) or halsulfuron plus dicamba (Yukon) give good control of both purple and yellow nutsedge. In a Roundup Ready tolerant crop, glyphosate combined with close cultivation with sweep type cultivators can also give effective control of nutsedge.

JOHNSONGRASS. Johnsongrass is a major problem in certain areas of California, especially where soils are difficult to dry down. Prevention is the key to johnsongrass control. Be especially diligent to prevent seedlings from becoming established. Once this weed is established on a farm, it is very difficult to eradicate. Johnsongrass seeds can get into irrigation water, manure, or lagoon water, and are easily spread throughout the farm. Ways to prevent its introduction are to ensure that feed is not contaminated with johnsongrass and to only use manure known to be well composted and free of weed seeds.

If a johnsongrass infestation does occur, there are several options to choose from in the management of this weed. In certain areas of the state, summer fallowing with a tillage operation every 3 to 4 weeks will give fair to good control by reducing carbohydrate reserves in rhizomes. Dry fallow is not effective in areas with a high water table where moisture in the soil is high enough throughout the summer to allow this weed to grow.

Glyphosate (Roundup) used in fallow periods, between crops, or when Roundup Ready (RR) varieties are grown can give effective control of rhizome johnsongrass during the growing season providing there is good soil moisture and active growth. Once glyphosate has been applied, allow about 7 to 10 days before discing to allow it complete translocation throughout the plant.

Preplant herbicide EPTC (Eradicane) can give rhizome suppression. Use the highest rate labeled for the soil type. EPTC, s-metolachlor (Dual Magnum), and alachlor (Micro-Tech) herbicides are effective in controlling johnsongrass seedlings before they emerge.

Nicosulfuron (Accent) as a postemergent banded treatment is very effective at controlling johnsongrass up to 1 foot tall and stopping the growth of johnsongrass up to 3 feet. Best corn yields are obtained by early (3- to 5-leaf) applications of nicosulfuron, which reduce early johnsongrass competition. If the first application time is missed, weed competition can be reduced by applying nicosulfuron with drop nozzles when the corn is 2- to 3-feet tall to control secondary flushes of seedlings in the row. As an additional measure, cultivate with sweep-type cultivators traveling at high speeds (5 to 6 mph) to throw 3 to 4 inches of soil to the base of the plant. The herbicide may also be applied as a band application in the corn row; johnsongrass growing in the areas between the rows can be destroyed by cultivation. Some growers may prefer to reduce weed competition by cultivating the furrows and applying this material with drop nozzles when the corn is 2- to 3-feet tall. This effectively controls secondary flushes of weed seedlings in the row. Cultivating the furrows after application and avoiding the use of nicosulfuron year after year in the same field will help prevent the development of resistance in johnsongrass to this herbicide.

Foramsulfuron (Option) is labeled for postemergent control of both seedling and rhizome johnsongrass up to 16 inches tall.

Cultivating the furrows after application and avoiding the use of nicosulfuron year after year in the same field will help prevent the development of resistance in johnsongrass to this material.

Rotating to broadleaf crops where clethodim (Prism), sethoxydim (Poast) and fluazifop-p-butyl (Fusilade) can be used is helpful in controlling johnsongrass between corn crops as can rotating to a Roundup Ready crop, such as alfalfa or cotton, where Roundup can be used for control.

BROADLEAVES. Some of the common broadleaves in corn include redroot pigweed, common lambsquarters, Palmer amaranth, annual morningglory, common sunflower, common purslane, horse purslane, annual morningglory, cocklebur, hairy nightshade, black nightshade, velvetleaf, and field bindweed.

Preplant herbicides alachlor (Micro-Tech) and S-metolachlor (Dual Magnum) are mainly grass herbicides but control some broadleaves such as nightshades and purslane. EPTC (Eradicane) controls the same weeds but also controls annual morninglory and lambsquarter.

Cultivation is important in controlling many small broadleaves. Broadleaves that emerge after the first irrigation when it's not possible to cultivate again because the corn is too tall can be controlled postemergent with 2,4-D. Dicamba (Banvel, Clarity) controls the same weeds and, in addition, is more effective on purslane, velvetleaf, and field bindweed. Dicamba and 2,4-D are low cost options but be careful because they can easily drift or volatilize onto sensitive crops and cause severe injury.

Bromoxynil (Buctril) and carfentrazone (Shark), both contact herbicides, are other postemergent option. For bromoxynil to be effective, weeds must be in the seedling stage or no larger than the size of a quarter. Carfentrazone, on the other hand, is effective on larger weeds (see label for details). These herbicides are a good choice to use as buffers near sensitive crops. Bromoxynil alone does not do an adequate job of controlling redroot pigweed.

Foramsulfuron (Option) is labeled for postemergent control of many broadleaves up to 2 to 3 inches tall.

Glyphosate (Roundup) for use on Roundup Ready (RR) varieties of corn is very effective in controlling many broadleaf weeds. It can also be tank mixed with selective herbicides; see label for RR variety information.

Metribuzin (Sencor) is a postemergent contact herbicide that is very effective at controlling broadleaf seedlings but does have some crop safety issues (see label).

Nicosulfuron (Accent) is very effective at controlling many small broadleaf seedlings after they germinate. It can be tank mixed with metribuzin, dicamba, or bromoxynil to broaden the weed control spectrum. Nicosulfuron is best used in conjunction with other methods of control including preplant incorporated herbicides and cultivation of furrows.

RESISTANT WEED MANAGEMENT ISSUES

An integrated approach to weed management is important in maintaining herbicide effectiveness. In some areas, use of EPTC (Eradicane) in the same fields year after year can lead to a decrease in the level of performance of this herbicide. The decrease is caused by a buildup of microbes in the soil that rapidly degrade the herbicide. To prevent this, use another preplant herbicide with different chemistry, such as alachlor or metolachlor. Also, avoid using nicosulfuron (Accent) or foramsulfuron (Option) in the same field for more than 2 consecutive years. Sulfonylurea weed resistance has developed rapidly because its mode of action is at a single site. Tank mixing with another herbicide, along with the use of cultivation in the furrows, will also reduce the risk of resistance developing to nicosulfuron. Use crop rotation or an herbicide of different chemistry if corn is grown several years in the same field.

In Roundup Ready crop systems in other states, weed shifts and weed resistance occurs. Weed shifts can occur when an herbicide program is used repeatedly, resulting in the survival of only weeds that are tolerant of the herbicide. Weed shifts also occur when the susceptible portion of a particular weed's population is controlled, but resistant biotypes of the weed survive and gradually produce a population that is resistant to the herbicide. Weed shifts are usually associated with reduced tillage systems and not rotating herbicides.

A major concern is the development of resistance to glyphosate (Roundup) by lambsquarter, amaranth, horseweed, and Italian ryegrass in California. Rotating glyphosate-resistant corn with another glyphosate-resistant crop such as cotton or alfalfa will increase this problem.

To help prevent the development of herbicide-resistant weeds and prevent weed shifts from occurring, it is important to incorporate tillage into your weed management practices as well as alternating herbicides that have a different chemical mode of action. Mode of action numbers are listed for the different herbicides used in corn in the HERBICIDE TREATMENT TABLE.

COMMON AND SCIENTIFIC NAMES OF WEEDS (1/06)

Common Name	Scientific Name
barley, hare	*Hordeum murinum* ssp. *leporinum*
barnyardgrass	*Echinochloa crus-galli*
bermudagrass	*Cynodon dactylon*
bindweed, field	*Convolvulus arvensis*
cocklebur, common	*Xanthium strumarium*
datura, sacred	*Datura wrightii*
goosefoot, nettleleaf	*Chenopodium* spp.
groundcherries	*Physalis* spp.
johnsongrass	*Sorghum halepense*
junglerice	*Echinochloa colona*
knapweed, Russian	*Acroptilon repens*
knotweed, common	*Polygonum arenastrum*
lambsquarters, common	*Chenopodium album*
lettuce, prickly	*Lactuca serriola*
morningglories	*Ipomoea* spp.
nightshade, black	*Solanum nigrum*
nightshade, hairy	*Solanum sarrachoides*
nightshade, silverleaf	*Solanum elaeagnifolium*
nutsedge, purple	*Cyperus rotundus*
nutsedge, yellow	*Cyperus esculentus*
oat, wild	*Avena fatua*
pigweed, redroot	*Amaranthus retroflexus*
puncturevine	*Tribulus terrestris*
purslane, common	*Portulaca oleracea*
purslane, horse	*Trianthema portulacastrum*
shattercane	*Sorghum bicolor*
sprangletops	*Leptochloa* spp.
spurge, spotted	*Chamaesyce maculata*
sunflower, common	*Helianthus annuus*
thistle, Russian	*Salsola tragus*
velvetleaf	*Abutilon theophrasti*
wheats	*Triticum* spp.

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (7/09)

	PREEMERGENCE							POSTEMERGENCE									
	ALA	ATR*	CAR	EPT	MET	PEN	YUK	BRO	DIC*	DIF	FOR	GLY	HAL	NIC	MTZ	PAR*	24D*
ANNUAL WEEDS																	
barley, hare	C	C	N	C	C	C	N	N	N	N	–	C	N	–	C	C	N
barnyardgrass	C	C	N	C	C	C	N	N	N	N	C	C	P	C	P	N	N
cocklebur, common	N	C	P	N	N	N	C	C	C	C	C	C	C	N	C	C	C
goosefoot	N	C	–	C	N	C	C	C	C	C	–	C	–	–	C	C	C
groundcherries	N	C	C	C	N	N	C	C	C	C	–	C	–	–	P	C	C
junglerice	N	–	N	–	N	C	N	N	N	N	–	–	N	–	–	–	N
knotweed, common	N	C	–	N	N	C	C	C	C	C	–	C	–	–	C	P	P
lambsquarters, common	P	C	C	C	P	C	C	C	C	C	C	C	P	N	C	P	C
lettuce, prickly	N	–	–	–	N	N	C	P	C	C	–	C	N	–	C	C	C
morningglories	P	C	C	C	P	N	C	C	C	C	P	C	P	C	N	–	C
nightshade, black	C	C	C	C	C	N	C	C	C	C	C	C	N	N	P	C	C
nightshade, hairy	C	C	C	C	P	N	C	C	C	C	C	C	N	N	N	C	C
oat, wild	–	C	N	C	–	P	N	N	N	N	C	C	N	P	N	C	N
pigweed, redroot	P	C	C	C	P	C	C	P	C	C	C	C	P	C	C	C	C
puncturevine	N	P	–	C	N	P	C	C	C	C	–	C	–	C	–	C	C
purslane, common	C	C	N	C	P	C	C	N	C	C	–	C	P	P	P	C	C
purslane, horse	C	C	N	–	C	C	C	N	C	C	–	P	–	–	–	–	P
shattercane	P	–	N	–	P	–	N	N	N	N	C	C	N	C	–	–	N
sprangletops	C	C	N	–	C	C	N	N	N	N	–	C	N	–	N	–	N
spurge, spotted	N	P	P	N	N	C	P	C	P	P	–	C	N	–	C	C	C
sunflower, common	N	N	P	N	N	N	C	C	C	C	C	C	C	P	P	–	C
thistle, Russian	N	C	–	N	N	P	C	C	C	C	–	C	–	–	C	P	C
velvetleaf	N	P	C	N	N	N	C	C	C	C	C	P	C	N	C	–	C
wheat (volunteer)	N	C	N	C	N	P	N	N	N	N	–	C	N	N	C	C	N
PERENNIAL WEEDS																	
bermudagrass (plant)	N	N	N	N	N	N	N	N	N	N	N	C	N	N	N	N	N
bermudagrass (seed)	N	C	N	P	N	N	N	N	N	N	N	C	N	–	N	P	N
bindweed, field (plant)	N	N	N	N	N	N	P	N	P	P	N	C	–	–	P	N	P
bindweed, field (seed)	P	C	P	N	P	P	C	P	C	C	N	C	–	–	P	P	C
datura, sacred	N	–	N	N	N	N	-	N	–	–	C	C	N	C	–	N	–
johnsongrass (plant)	N	N	N	P	N	N	N	N	N	N	C	C	N	C	N	N	N
johnsongrass (seed)	P	C	N	P	P	P	N	N	N	N	C	C	N	C	N	P	N
knapweed, Russian	N	–	N	N	N	N	–	N	–	–	–	C	–	–	–	N	–
nightshade, silverleaf	N	–	N	N	N	N	C	N	C	C	–	C	N	–	–	N	C
nutsedge, purple	N	N	N	C	N	N	C	N	N	N	N	P	C	N	N	N	N
nutsedge, yellow	C	N	N	C	C	N	C	N	N	N	N	P	C	N	P	N	N

ALA = alachlor* (Micro-Tech)
ATR = atrazine* (AAtrex, etc.)
BRO = bromoxynil (Buctril)
CAR = carfentrazone (Shark)
DIC = dicamba* (Banvel, Clarity)
DIF = diflufenzopyr (Distinct)
EPT = EPTC (Eradicane)
FOR = foramsulfuron (Option)
GLY glyphosate** (Roundup)

HAL = halosulfuron (Sandea)
MET = s-metolachlor (Dual Magnum)
MTZ = metribuzin (Sencor)
NIC = nicosulfuron (Accent)
PAR = paraquat* (Gramoxone Inteon)
PEN = pendimethalin (Prowl, Prowl H2O)
24D = 2,4-D*
YUK = halsulfuron/dicamba (Yukon)

C = control (Depends on weed size and herbicide rate)
P = partial control
N = no control
– = no information

* Permit required from county agricultural commissioner for purchase or use.
** Only for transgenic varieties of corn that contain specific herbicide-resistant genes.

HERBICIDE TREATMENT TABLE (7/09)

Common name (trade name)	Amount/Acre	R.E.I.+ (hours)	P.H.I.+ (days)
BEFORE PLANTING			
A. ALACHLOR* (Micro-Tech) EC	2.5–3 lb a.i. 2.5–3 qt	12	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 15 COMMENTS: Apply after preirrigation and incorporate in top 2 inches of soil within 7 days of planting.			
B. ATRAZINE* (AAtrex 4L, Atrazine 4L)	1.6–2 lb a.i. 3.2–4 pt	12	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 5 COMMENTS: Do not rotate to any crop except corn or sorghum for 18 months after use. Band application can reduce carryover. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.			
C. EPTC (Eradicane) 6.7E	3.14–6.138 lb a.i. 3.75–7.33 pt	12	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 8 COMMENTS: Immediate incorporation is necessary. Use high rates for perennial weeds. Requires cross-discing for best results. Some corn varieties are sensitive to injury with this material; check with corn seed companies to insure a variety is tolerant before using. Do not apply greater than 4.75 pt/acre in the 10 southernmost counties of California. Soils lacking enough moisture for seed germination must be pre-irrigated before application.			
D. GLYPHOSATE (Roundup, etc.)	1.375–4.5375 lb a.i. 1–3.3 qt	4	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 9 COMMENTS: A nonselective herbicide; apply to emerged weeds. Do not allow spray mist to contact desirable plants. Use with a nonionic surfactant.			
E. S-METOLACHLOR (Dual Magnum)	1.42875–2.38 lb a.i. 1.5–2.5 pt	24	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 15 COMMENTS: Apply after preirrigation and incorporate into the soil.			
F. PARAQUAT* (Gramoxone Inteon)	0.5–1 lb a.i. 2–4 pts	24	NA
WSSA MODE OF ACTION GROUP NUMBER[1]: 22 COMMENTS: Apply as a contact broadcast spray to emerged weeds. Use a nonionic surfactant.			
AT PLANTING			
A. ALACHLOR* (Micro-Tech) EC	2.5–3 lb a.i. 2.5–3 qt	12	see comments
WSSA MODE OF ACTION GROUP NUMBER[1]: 15 COMMENTS: Apply after preirrigation and incorporate in top 2 inches of soil within 7 days of planting. Do not apply after corn is 5 inches tall.			
B. ATRAZINE* (Aatrex 4L, Atrazine 4L)	1.6–2 lb a.i. 3.2–4 pt	12	see comments
WSSA MODE OF ACTION GROUP NUMBER[1]: 5 COMMENTS: Do not follow with any crop except corn or sorghum for 18 months after use. Band application can reduce carryover. PHI for Aatrex is 0; for Atrazine it is 45 days for sweet corn and 60 days for field corn. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.			

Common name (trade name)	Amount/Acre	R.E.I.+ (hours)	P.H.I.+ (days)
C. S-METOLACHLOR	1.42875–2.38 lb a.i.		
(Dual Magnum)	1.5–2.5 pt	24	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 15			
COMMENTS: Apply after preirrigation and incorporate into soil.			
D. PENDIMETHALIN	Label rates		
(Prowl) 3.3EC	1–2 qt	24	0
(Prowl H2O)	1–2 qt	24	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 3			
COMMENTS: Irrigate to activate; do not incorporate. Do not apply to no-till corn. Plant at least 1.5 inches deep. Do not use on peat soils.			
E. GLYPHOSATE	1.375–4.5375 lb a.i.		
(Roundup)	1–3.3 qt	4	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 9			
COMMENTS: Apply to emerged weeds but before corn emerges. Do not allow spray mist to contact desirable plants. Use with a nonionic surfactant.			
F. PARAQUAT*	0.5–1 lb a.i.		
(Gramoxone Inteon)	2–4 pts	24	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 22			
COMMENTS: Apply as a contact broadcast spray to emerged weeds. Use a nonionic surfactant.			
G. EPTC	3.14–3.978 lb a.i.		
(Eradicane) 6.7E	3.75–4.75 pt	12	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 8			
COMMENTS: Immediate incorporation is necessary. Use high rates for perennial weeds. Requires cross-discing for best results. Some corn varieties are sensitive to injury with this material; check with corn seed companies to insure a variety is tolerant before using. Do not apply greater than 4.75 pt/acre in the 10 southernmost counties of California. Soils lacking enough moisture for seed germination must be pre-irrigated before application.			
AFTER PLANTING			
A. NICOSULFURON	0.015–0.03093 lb a.i.		
(Accent) WDG	0.33–0.66 oz	4	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 2			
COMMENTS: Do not apply to sweet corn. Apply postemergent until corn is 20 inches tall or 6 leaf stage of corn, whichever comes first, then use drop nozzles up to 36 inches. Keep spray out of whorl. Injury will occur if applied to stressed corn and it won't effectively control stressed weeds. See label for cultivation restrictions. Deep plowing will reduce risk of carryover. Must use with surfactant or COC (crop oil concentrate). Use a minimum of 15 gpa for best performance. Use higher rates as weed size increases. Nicosulfuron can be tank mixed with dicamba or bromoxynil to broaden the weed control spectrum. This material is best used in conjunction with other methods of control to reduce the risk of the development of resistance by weeds.			
B. PENDIMETHALIN	0.825–1.65 lb a.i.		
(Prowl) 3.3 EC	1–2 qt	24	0
WSSA MODE OF ACTION GROUP NUMBER[1]: 3			
COMMENTS: Apply as culti-spray after brace roots are formed. May contribute to lodging. Pendimethalin can be active up to 6 months; check the label for plant-back restrictions. Will not control emerged weeds.			
C. GLYPHOSATE (Roundup, Weathermax, Original, etc.)	Label rates	see label	see label
WSSA MODE OF ACTION GROUP NUMBER[1]: 9			
COMMENTS: Can be applied as a spot treatment, but apply before corn silks in conventional corn varieties. Corn in treated area will be killed unless it is a Roundup-tolerant variety. Do not allow spray mist to contact desirable plants. Use with a nonionic surfactant. In Roundup Ready varieties glyphosate can be applied over the top to corn up to the V8 stage of corn or 24 inches. Drop nozzles are recommended for corn taller than 24 inches. Keep spray out of whorls after corn is 30 inches tall. Rates depend on formulation and weed type and size. Must sign technology agreement. Application of 1-2 percent dry ammonium sulfate by weight per 100 gal. of water may increase performance. Use extreme care to prevent drift onto nonRoundup Ready crops.			

	Common name (trade name)	Amount/Acre	R.E.I.+ (hours)	P.H.I.+ (days)
D.	2,4-D*	0.2375–0.475 lb a.i.		
	(Amine)	0.5–1 pt	48	see comments

WSSA MODE OF ACTION GROUP NUMBER[1]: 4

COMMENTS: Apply from crop emergence to tasseling. Apply over the top when corn is less than 8 inches tall. Use drop nozzles when corn is more than 8 inches tall, keeping spray mist out of whorl. Don't use when corn is over 3 feet tall or when brace roots have formed. Do not spray when temperature is expected to exceed 95°F. High drift potential; keep away from sensitive crops. Tanks must be thoroughly cleaned because even minute amounts of residue will cause injury to broadleaf crops. In many areas there are restrictions limiting use of this material. Delay cultivation 8-10 days to prevent stalk breakage due to temporary brittleness caused by 2,4-D. PHI for field and popcorn is 0 days; for sweet corn it is 45 days.

E.	DICAMBA*			
	(Banvel)	0.25–0.5 lb a.i. (0.5–1 pt)		
	(Clarity)	0.5 lb a.i. (16 fl oz)	24	0

WSSA MODE OF ACTION GROUP NUMBER[1]: 4

COMMENTS: Do not use on sweet corn. Apply over the top when corn is less than 8 inches tall. Use drop nozzles when corn is more than 5 leaves or 8 inches tall. Apply postemergence until corn is 36 inches tall or until 15 days before tassels emerge. Keep herbicide out of the whorl of the plant to avoid yield loss. Do not apply when temperature is expected to exceed 85°F. High drift potential; keep away from sensitive crops. Keep spray pressure below 20 psi. Tanks must be thoroughly cleaned because even minute amounts of residue will cause injury to broadleaf crops. In many areas there are restrictions limiting the use of this material. Clarity has less potential to move off target than Banvel. Do not cultivate within 7 days after application. Applications during rapid growth may result in temporary leaning.

F.	DIFLUFENZOPYR*	0.175–0.2625 lb a.i.		72–grain
	(Distinct)	4–6 oz	12	32–corn forage

WSSA MODE OF ACTION GROUP NUMBER[1]: 19

COMENTS: For use in field corn and popcorn. Used to control annual broadleaves and control/suppress many perennial broadleaves. Tank-mix or use sequentially with a grass herbicide.

G.	BROMOXYNIL	0.125–0.25 lb a.i.		
	(Buctril)	0.5–1 pt	24	0

WSSA MODE OF ACTION GROUP NUMBER[1]: 6

COMMENTS: For field corn and popcorn only. Apply after crop emergence but before tassels emerge. Weed should be less than 4 inches tall. Can be used where drift of dicamba or 2,4-D may injure sensitive broadleaf crops. Do not apply to sweet corn. Combinations of bromoxynil with other broadleaf herbicides enhance weed control.

H.	PARAQUAT*	0.25–0.5 lb a.i.		
	(Gramoxone Inteon)	1–2 pts	24	0

WSSA MODE OF ACTION GROUP NUMBER[1]: 22

COMMENTS: Apply to emerged weeds. Use shielded spray when corn is at least 10 inches. Do not allow spray mist to contact corn plants. Use a nonionic surfactant.

I.	METRIBIZIN	0.075–0.14 lb a.i.		
	(Sencor) 75 DF	1.6–3 oz	12	60

WSSA MODE OF ACTION GROUP NUMBER[1]: 5

COMMENTS: Do not use on corn grown for seed, sweet corn, popcorn, or white corn. Use postemergence as a tank mix with nicosulfuron (Accent), atrazine (AAtrex, etc.), dicamba (Banvel), bromoxynil (Buctril), or 2,4-D to increase number of species controlled, improve control of larger weeds, and/or reduce herbicide rates (see label). The mixture with nicosulfuron is allowed by a 2ee label (CASNPB96.074), which is not on the container label. The maximum size of corn or weeds and the use of broadcast or directed sprays varies with the tank mixture being applied. Do not apply when the corn is under stress, including very dry or very wet soil conditions. Do not use on sand, loamy sand, or sandy loam soils that have less than 0.5% organic matter. Do not use crop oil concentrate (COC) or any adjuvant containing vegetable or petroleum oils with any metribuzin tank mixture as severe leaf burn, crop stunting, and/or stand reduction may occur.

	Common name (trade name)	Amount/Acre	R.E.I.+ (hours)	P.H.I.+ (days)
J.	ATRAZINE*	1.6–2 lb a.i.		
	(Aatrex 4L, Atrazine 4L)	3.2–4 pt	12	see comments
	WSSA MODE OF ACTION GROUP NUMBER[1]: 5			
	COMMENTS: Do not rotate to any crop except corn or sorghum or injury will occur. Band application can reduce carryover. PHI for Aatrex is 0; for Atrazine it is 45 days for sweet corn and 60 days for field corn. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.			
K.	HALOSULFURON	0.0309–0.0623 lb a.i.		
	(Sandea)	0.66–1.33 oz	12	30
	WSSA MODE OF ACTION GROUP NUMBER[1]: 2			
	COMMENTS: For use on field corn or field corn grown for seed. Can be applied to sweet corn or popcorn however at lower use rates. Apply over corn beginning at the spike stage until row closure, or until the height of the corn prevents coverage of weed with spray. To avoid the development of resistance to this herbicide by weeds, do not use this material in consecutive years. See label for spray rates and application timing, which are based on weed size. Can be tank mixed with dicamba (Banvel), 2,4-D, or bromoxynil (Buctril) to increase the spectrum of weeds controlled or if weed size is too large for just halosulfuron alone. Can also be tank mixed with glyphosate in Roundup Ready varieties**.** Use a nonionic surfactant. Allow 30 days before harvesting for silage. Allow 9 months before planting back to alfalfa.			
L**.**	CARFENTRAZONE	0.000306 lb a.i.		
	(Shark)	0.33 oz	12	0
	WSSA MODE OF ACTION GROUP NUMBER[1]: 14			
	COMMENTS: Apply in all tillage systems up to 30 days before planting and afterwards up to 8-leaf stage of corn. Do not apply more than 1.24 oz/season. For best performance apply to weeds before weeds exceed 4 inches. However, can be applied to velvetleaf up to 18 inches tall, or 36 inches tall with drop nozzles. Do not apply to stressed crops or use with an oil concentrate or severe speckled leaf burn may occur. Tank mixing with 2,4-D, Clarity, or Accent will widen the weed control spectrum. Can also be tank mixed with glyphosate in Roundup Ready systems.			
M.	HALOSULFURON/DICAMBA*	0.16875–0.3375 lb a.i.		
	(Yukon)	4–8 oz	12	see label
	WSSA MODE OF ACTION GROUP NUMBER[1]: 2/4			
	COMMENTS: For use on field corn and field corn grown for seed. Can be applied over-the-top or with drop nozzles from the spike through 36 inches. May be applied up to 2 applications not to exceed 8 ounces. Allow at least 2 weeks between applications. Allow 9 months before planting back to alfalfa.			
N.	FORAMSULFURON	0.03281 lb a.i.		Grain: 70
	(Option)	1.5 oz	12	Forage: 45
	WSSA MODE OF ACTION GROUP NUMBER[1]: 2			
	COMMENTS: Provides postemergent control or suppresses many annual grasses and certain broadleaves in field corn. Temporary yellowing or stunting may occur. Corn quickly outgrows these effects. The recommended additives are methylated seed oil (MSO) at 1.5 pt/acre plus 28% nitrogen at 2 qt/acre or ammonium sulfate at 3 lb/acre. Apply when annual grasses are 2 to 4 inches tall and before corn exceeds V5 or 16 inches, whichever comes first. Drop nozzles must be used to corn that is greater than V6 and less than V8 stage of growth. Do not apply to corn more mature than V8 (8 visible leaf collars) stage of growth. Can interact with organophosphate insecticides to cause severe corn injury; see label for specific restrictions pertaining to organophosphates.			

\+ 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.