UC IPM
Pest Management Guidelines:
RICE

June 2019

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

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

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UC PEER REVIEWED

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The UC IPM Pest Management Guidelines are available from:

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

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

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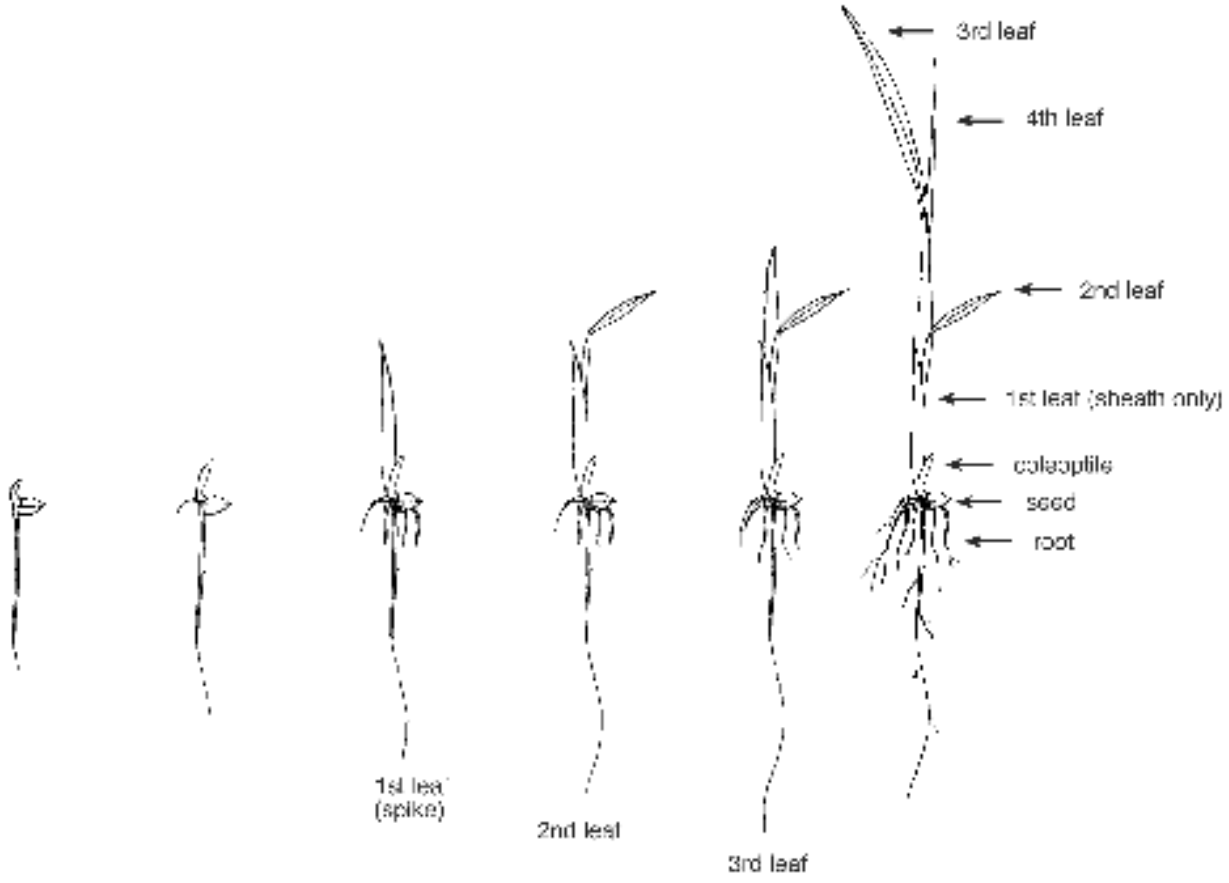
To be used with *Integrated Pest Management for Rice,* 2nd EditionUC ANR Publication 3280.

General Information

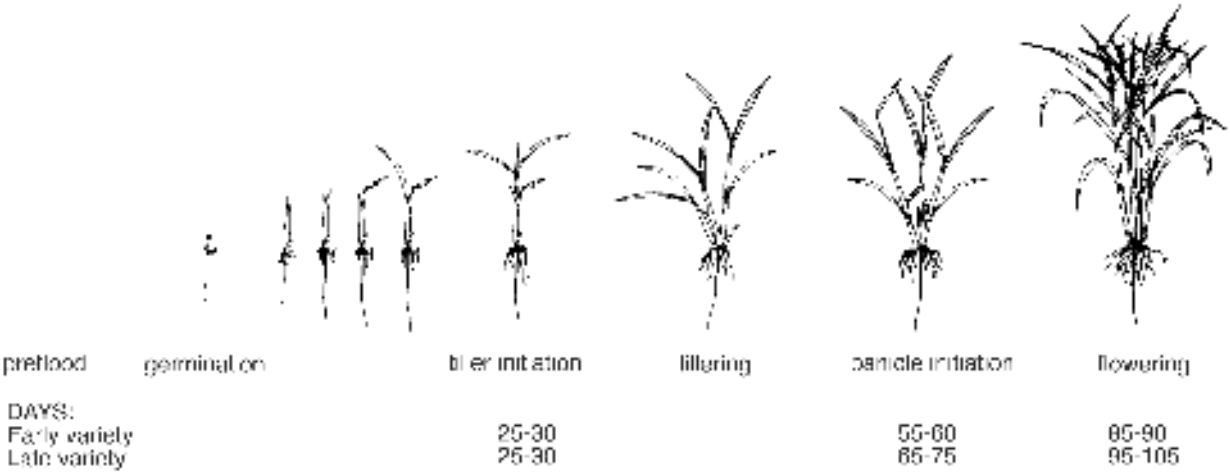
(Section reviewed 4/04)

RICE DEVELOPMENTAL STAGES (4/04)

Development of Rice Seedling



Number of Days from Germination to Flowering



TREATMENT PERIODS FOR MOST EFFECTIVE CONTROL IN AN IPM PROGRAM (4/04)

SEED SOAKING

Seed rot and seedling disease

SEEDLING STAGE 1 (TO 3-LEAF STAGE)

Grass weeds
Broadleaf and sedge weeds
Rice water weevil
Tadpole shrimp

SEEDLING STAGE 2 (TO 5-LEAF STAGE)

Rice leafminer
Algae

EARLY TILLERING

Grass weeds
Broadleaf and sedge weeds—Resistant biotypes

LATE TILLERING

Perennial weeds—Gregg arrowhead, Ricefield bulrush

MANAGING MOSQUITOES IN AN AGRICULTURAL SITUATION (4/04)

Rice culture, as well as other irrigated agricultural situations, can provide a suitable environment for mosquito breeding. In cases where these agricultural lands interface with urbanized or public areas, mosquitoes can be a public nuisance, and certain mosquito species can create health problems for humans and livestock. *Culex tarsalis* and several other species can transmit the viruses that cause encephalitis, including *West Nile Virus*. *Anopheles freeborni* can transmit the pathogens that cause malaria.

Mosquito control in rice fields is often carried out primarily by mosquito abatement or vector control personnel who are authorized to visit rice fields and treat for mosquito infestations. Mosquito Abatement or Vector Control Districts combine a variety of methods to manage mosquitoes in rice fields including insecticide application and stocking fields with the mosquito-eating fish, *Gambusia affinis*. Some mosquito control agencies use the bacteria *Bacillus thuringiensis israelensis* (Bti) and *B. sphaericus* (Bs), which are effective in killing mosquito larvae, yet have low toxicity to other organisms. Agencies also use ultra-low volume pesticide fogs to control flying adult mosquitoes in rice-growing areas (usually pyrethroids or malathion). These fogs do not kill the fish, insects, and some of the other invertebrates in the water.

In addition to the control measures taken by mosquito abatement districts, there are numerous cultural practices growers can take to reduce the rice field's desirability as a mosquito-breeding site.

- Construct access roads around each field for checking and repairing levee breaks and for mosquito abatement personnel to use to check fields.
- Drain and eliminate borrow pits and seepage areas external to the field.
- Seek assistance of your local mosquito abatement district staff to develop the best possible abatement program for a field.
- Check with abatement district personnel to find out how to minimize impacts of pesticides used in your pest management program on mosquito-eating fish, and notify them if disruptive pesticides are used later in the season than May so that they can monitor the fish populations.

PRESERVING MOSQUITO PREDATORS

Many insects occurring naturally in rice fields are predators of mosquitoes. These include backswimmers, scavenger beetle larvae, giant water bugs, predaceous diving beetles and their larvae, and damselfly and dragonfly nymphs. While these useful predators consume the majority of mosquito larvae, supplemental mosquito control is usually necessary because the low percentages that survive still represent very large numbers. It is very important, however, to conserve the natural predators that accomplish most mosquito control. Whenever possible, follow good integrated pest management practices for invertebrate pests so that the use of broad-spectrum pesticides can be minimized. This will facilitate the survival of mosquito fish and other natural enemies of mosquitoes and help to minimize buildup of mosquito populations.

RELATIVE TOXICITIES OF PESTICIDES USED IN RICE TO NATURAL ENEMIES AND HONEY BEES (10/15)

Common name (example trade name)	Mode of action[1]	Selectivity[2] (affected groups)	General predators[3]	Parasites[3]	Honey bees[4]	Mosquito fish (*Gambusia* sp.)	Duration of impact to natural enemies[5]
carbaryl (Sevin 4F)	1A	broad (insects, other invertebrates)	H	H	I	H	long
carbaryl (Sevin XLR Plus)	1A	broad (insects, other invertebrates)	H	L	I	H	long
clothianidin (Belay)	4A	lygus, aphids	M/L	M/L	I	—	long
copper sulfate pentahydrate	—	narrow (insects, other invertebrates)	M	L	III	M	moderate
diflubenzuron (Dimilin)	15	narrow (insects, other invertebrates)	M	L	II	L	moderate
lambda-cyhalothrin (Warrior)	3A	broad (insects, other invertebrates)	H	H	I	H	long
malathion	1B	broad (insects)	H	H	I	L/M	moderate
zeta-cypermethrin (Mustang)	3A	broad (insects, other invertebrates)	M	M	I	H	long

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

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

4 Ratings are as follows: I–Do not apply or allow to drift to plants that are flowering including weeds. Do not allow pesticide to contaminate water accessible to bees including puddles. II–Do not apply or allow to drift to plants that are flowering including weeds, except when the application is made between sunset and midnight if allowed by the label and regulations. Do not allow pesticide to contaminate water accessible to bees including puddles. III–No bee precaution, except when required by the label or regulations. For more information about pesticide synergistic effects, see *Bee Precaution Pesticide Ratings (available online at http://ipm.ucanr.edu/beeprecaution/)*.

5 Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.

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

Invertebrates

(Section reviewed 4/04)

ARMYWORMS (10/15)

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

;Pesticides updated 10/15; Corrected 5/19

DESCRIPTION OF THE PESTS

Two species of armyworms, the armyworm and the western yellowstriped armyworm, are found in rice fields in mid-summer. Spring and early summer generations are spent on other plants. When other food sources are depleted, larvae of either species may migrate into rice paddies, or adult moths may fly into the rice field to lay eggs.

The armyworm moth lays its eggs in linear masses with the leaf tied around the eggs in a roll on either rice or other grass species in the field.

The western yellowstriped armyworm moth is believed to restrict its egg laying in rice fields to broadleaf weeds. Eggs occur in the form of a flattened mass that is covered by body scales. Both larvae are striped and vary in body color but the older worms can be distinguished by markings on their sides. The western yellowstriped armyworm has a black spot on the side of its first legless segment, and the centers of spiracles on each body segment are white. The first legless segment of the armyworm does not have a dark spot and the center of each spiracle is black.

Larvae feed predominantly at night or during cloudy days. They develop to full size and pupate in about 3 to 4 weeks in summer. Pupation normally takes place in the upper surface of the soil or in debris, consequently most mature larvae drown in flooded paddies before reaching a suitable pupation site. Usually only one generation a year will be spent on rice.

Adult moths of both species have a wingspan of about 1.5 inches (about 35–45 mm). The western yellowstriped moth has mottled forewings and silver and gray hindwings. The armyworm adult has a single white spot in the middle of its buff-colored forewing. Both moths fly at night.

DAMAGE

Injury by armyworms is most serious during periods of stem elongation and grain formation. Larvae defoliate plants, typically by chewing angular pieces off leaves. They may also feed on the panicle rachis near the developing kernels causing these kernels to dry before filling. This feeding causes all or parts of the panicle to turn white. If the entire panicle is white, injury may also be due to low nighttime temperatures during panicle differentiation, stem rot or feeding by rats. The seriousness of armyworm injury depends on the maturity of the plant and the amount of tissue consumed. Significant yield reduction can occur if defoliation is greater than 25% at 2 to 3 weeks before heading.

MANAGEMENT

Early broadleaf weed control and biological control can be important in limiting the numbers of armyworms. Monitor throughout the summer to assess the need to treat.

Biological Control

Various natural factors cause mortality of armyworms in the rice field. Many caterpillars drown or are killed by natural enemies including predators, pathogenic microorganisms, and parasites. Natural enemies, especially when they limit spring and early summer generations in other crops and along field margins, often keep armyworms from becoming pests in rice. The wasp *Hyposoter exiguae* often parasitizes the western yellowstriped armyworm, and *Apanteles militaris* is the most commonly seen parasite of the armyworm. The larvae of these wasps live within the armyworms until they emerge to form white silk cocoons on tillers and leaves.

Cultural Control

The western yellowstriped armyworm is believed to limit its egg laying to broadleaf plants; thus, the early control of broadleaf weeds in rice fields may be important in limiting its populations.

Organically Acceptable Methods

Biological and cultural controls are acceptable for use on an organically certified crop.

Monitoring

Foliar Injury

Monitor for foliar injury from panicle differentiation to heading by looking for signs of armyworms feeding on leaves. Once you begin to observe injury, start taking samples twice a week until grain start maturing or larvae are no longer present. To sample, choose a part of the field where you have observed injury. Select a plant at random and pull it up or move all the surrounding foliage away and check for defoliation. Check the plant from the top of the leaves to the base of the plant and the water surface for armyworms. Determine if 25% or more of the foliage has been removed by armyworms; also note if you find armyworms on neighboring weeds or rice plants. Record your observations on a monitoring form. Repeat this procedure every 5 to 10 feet (1.5–3 m) across a transect until 10 plants have been examined. Move to a different part of the field where feeding is evident and examine 10 more plants in the same manner. Repeat this procedure at several areas of the field until you are confident that you have an estimate of the average field condition.

Panicle Loss

Monitor for panicle loss after panicle emergence by checking for entire panicles or parts of panicles that have turned white; these indicate armyworm feeding. Be sure to differentiate this injury from stem rot, which may kill the entire panicle and darken the stems. Once you begin to observe armyworm injury to the panicle, take samples twice a week to determine the need for treatment. Use a sampling ring made of plastic tubing that encloses 1 square foot. Select your sampling sites in parts of the field with white panicles. Drop the ring at your side without looking. Examine all the plants within the ring down to the water level for armyworms; at the same time check for stem rot. Record the number of panicles and the percentage of them that are white and the presence or absence of armyworms within the ring. Move on 5 to 10 feet and repeat the procedure until 10 samples have been taken. Move to another area of the field with signs of panicle injury and take 10 more samples. Repeat the 10-sample procedure until you feel that you have a good estimate of the field condition.

Treatment Decisions

From panicle differentiation through heading, treat for foliar damage only in those areas of the field where 5 or more of the 10 samples taken have over 25% defoliation and armyworms are present on the plants. If you observe a few or no armyworms, come back at night to check for the larvae, which are more active after dark. Do not treat if armyworms are not present, especially during late August, because they have probably completed development.

From panicle emergence to grain maturity, treat for panicle loss if 10% of the panicles in the area sampled are damaged and armyworms are observed. If armyworms are not observed but panicle loss is 10% or more, check for the larvae at night. If larvae are not found, do not treat because they have probably pupated and will do no further damage. Limit treatments to those areas of the field with economic damage.

	Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	UPDATED 10/15			
	Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A.	LAMBDA-CYHALOTHRIN* (Warrior II with Zeon)	1.6–2.56 fl oz	24	21
	MODE-OF-ACTION GROUP NUMBER1: 3A COMMENTS: Can be used safely when propanil products are being used for weed control. Notify the mosquito vector control district personnel so that they can monitor populations of mosquito fish after use of this product. Do not apply more than 0.96 pts/acre per season.			
B.	ZETA-CYPERMETHRIN* (Mustang)	3.4–4.3 oz	12	14
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Make applications at least 7 days apart and do not release flood water within 7 days of application. Do not apply more than 1.1 pt (0.2 lb a.i.)/acre per season. Notify the mosquito vector control district personnel so that they can monitor populations of mosquito fish after use of this product.			

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
C. CARBARYL*			
(Sevin 4F)	1-1.5 qt	12	14
(Sevin XLR Plus)	1-1.5 qt	12	14
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not apply 15 days before or after application of the herbicide propanil.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of 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/.

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

ASTER LEAFHOPPER (10/15)

Scientific Name: *Macrosteles fascifrons*

DESCRIPTION OF THE PEST

Several species of leafhoppers feed on rice plants in California, but the only one known to be of economic importance is the aster leafhopper. The adults are about 0.125 inch long, with transparent wings that are strongly veined, and body background colors of gray and black. The nymphs have small wing pads in their last instar and range in color from yellow to dark green.

Leafhoppers usually pass the winter in the egg stage, although nymphs and adults may be found all year round. The leafhopper inserts its eggs into tender plant tissues. Wingless nymphs hatch from the eggs and go through four to five molts before reaching maturity. Up to six generations may be completed between spring and fall.

DAMAGE

Although leafhoppers can be present in fields during most of the growing season, the heaviest populations usually occur from early July through mid-August. Leafhoppers feed on rice plants by sucking up plant fluids through their long, piercing mouthparts. Although they are not known to vector of any rice pathogens in California, leafhoppers may occasionally occur in sufficient numbers to cause damage by their feeding. Injury associated with leafhoppers include stippling, yellowing, and drying leaves. Leafhoppers prefer senescing leaves, and symptoms usually occur on older leaves first. Leafhoppers are very mobile; adults fly and nymphs jump. Thus, infestations are rarely localized but appear generally throughout the field.

MANAGEMENT

High populations of this pest are associated with weedy rice fields. Control weeds and monitor during the summer to determine the need to treat. Predation can provide significant reduction of leafhopper populations.

Biological Control

Small plot studies in rice paddies have shown a spider, *Pardosa ramulosa,* to significantly reduce populations of the aster leafhopper.

Cultural Control

High populations of aster leafhoppers are frequently associated with paddies heavily infested with broadleaf weeds and sedges. An early and effective weed control program is an important way to discourage the development of economically damaging populations of leafhoppers on weeds and future movement of leafhoppers to rice.

Organically Acceptable Methods

Cultural controls, such as described above, and reliance on biological control are organically acceptable methods.

Monitoring and Treatment Decisions

Observe fields weekly from July through August for leafhoppers and their damage. Leaf yellowing and stippling can be associated with other stresses, so always check for the presence of leafhoppers. Leafhopper adults, nymphs, and molted skins are easy to see as you walk slowly through a field. Always inspect fields carefully after broadleaf herbicide treatment; the killing of broadleaf weeds may cause the leafhoppers to move from the dying weeds to the rice plants. Although there are no available treatment thresholds, a good rule of thumb is to treat when young upper leaves become infested and begin to dry.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A. CARBARYL* (Sevin 4F)	1–1.5 qt	12	14

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
(Sevin XLR Plus)	1–1.5 qt	12	14
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not apply within 15 days before or after application of propanil or crop injury may result.			

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

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

CRAYFISH (2/09)

Scientific Names: *Procambarus clarkii* and *Orconectes virilis*

DESCRIPTION OF THE PEST

The most common crayfish in rice fields is the red crayfish, *Procambarus clarkii*, but *Orconectes virilis*, an olive-green colored crayfish, may also be found in canals and streams associated with rice fields. Crayfish reproduce once a year. Mating takes place anytime between spring and autumn. Eggs hatch in fall or following spring. Young crayfish usually remain in the mother's burrow until they molt three times. After leaving the burrow, they molt six to seven more times before reaching maturity. Adult crayfish may live up to 2 years and molt two to four more times, growing to a length of 3 to 4 inches. Their burrows are scattered along ditches, levee banks, and in the field. The crayfish may excavate their water-filled burrows to a depth of 3 feet. When the field is drained, crayfish retreat to their burrows or migrate. If the burrows remain moist, crayfish can survive at least until the next season and maybe longer.

DAMAGE

Crayfish are of serious concern because their burrowing in ditches and levee banks may disrupt the irrigation network. Burrows near head gates and weir boxes often make it impossible to maintain an acceptable water head. Crayfish burrowing and swimming may also muddy the water, reducing photosynthesis in submerged plants. Soil forced up around burrows by crayfish after the field is drained may be picked up by harvesting machinery and contaminate harvested grain.

Crayfish occasionally eat rice seeds and seedlings, and their digging may uproot seedlings as well. Floating leaf parts caused by crayfish may resemble feeding by the tadpole shrimp but crushed or macerated, submerged rice seed is unique to crayfish. Extensive injury of this sort has not been a frequent or widespread problem and is mainly associated with fields that are in rice several consecutive seasons.

MANAGEMENT

Cultural practices, such as fallowing or temporarily draining fields, are the key methods available for crayfish control. Pesticides are not registered.

Cultural Control

Check the irrigation system for crayfish damage all season long. Repair damage to levees, field weir boxes, and major irrigation structures as soon as possible to prevent accidental draining of the field.

If rice plant stand drops below acceptable levels (25–30 seeds or seedlings per square foot) during the first 2 weeks after flooding and damage caused by crayfish is evident, you can temporarily drain the field to drive the crayfish into their burrows until the rice seedlings are well established. This does not kill the crayfish, but the seedlings are not as susceptible to injury when older. A decision to drain must take into consideration negative aspects such as fertilizer loss, encouragement of weeds or interruption of weed control procedures, interruption of pesticide drainage requirements, and the economics of irrigation.

Leaving fields fallow for a year or more will deter crayfish populations, but the time of fallowing required and crayfish survival may vary depending on the water table, degree of cultivation, and other factors.

Organically Acceptable Methods

Drainage and fallowing, as described above under cultural controls, are organically acceptable management methods.

Treatment Decisions

No chemicals are registered for crayfish control.

RICE LEAFMINER (10/15)

Scientific Name: *Hydrellia griseola*

DESCRIPTION OF THE PEST

The rice leafminer adult is a small, olive-green fly (0.018 inch long) commonly found in the early-season walking on the water surface or on rice leaves lying on the water surface. The females lay their elongate, white eggs singly on the upper surface of these leaves. They prefer leaves floating on the water, and high humidity (80–100% relative humidity) is required for hatching. In 3 to 5 days, eggs hatch into cream-colored, maggot-shaped larvae. The larvae burrow between the outside leaf layers and mine the leaf. Larvae may pupate in an existing mine or migrate to a different leaf to form a new mine. Total development time from egg to adult is about 2 weeks at 85° to 90°F. Rice leafminers generally overwinter as adult flies, and they may begin to lay eggs on leaves of a wide range of grasses associated with aquatic habitats as early as February.

DAMAGE

Injury is caused by leafminer larvae feeding in mines between the two epidermal layers of a leaf. The mines usually contain a swelling, which is the body of the feeding or pupating leafminer. The mined area on the leaf fades to a light green color at first, then turns yellow and may appear white with time if it dries. Because high humidity is required for hatching, leafminer infestations are usually confined to leaves lying on the water surface. The larvae are mobile and move on to new leaves after old ones are completely mined. In severe infestations, they may also mine the leaf sheath.

Plant vigor and weather conditions govern the extent and seriousness of the injury. Any factor affecting plant growth, especially deep water culture or cool weather, that increases the number of leaves remaining prostrate on the water or the length of time they are fully in contact with water will extend the period of susceptibility. Seedling leaf loss and the resulting reduction in photosynthesis, is critical at this time as food reserves from the seed have already been depleted to get the plant through the water. The plant is usually able to put forth additional leaves, but continued mining can result in reduced tillering, greater susceptibility to later pest attack, delayed maturity, or death of the plant. Once leaves start growing upright above the water, the rice leafminer does not cause economic damage.

MANAGEMENT

Leafminers can be found in every field every year, but the seriousness of their attack will be closely related to the speed with which the plant grows erect and out of the water. The temperature of the air and water, plant vitality, and water depth all play a role. Manage water levels in the field to encourage the rice to emerge quickly and grow erect. Monitor for rice leafminers to determine the need to treat. Although populations of leafminer parasites can be high in rice fields, they generally do not build up to adequate levels early enough to prevent economic damage from the first generation.

Biological Control

Several parasitic wasps attack the rice leafminer. The most effective are *Chorebus aquaticus* and *Opius hydrelliae*. Parasites control up to 50% of the generations of leafminers that feed on grasses before rice fields are flooded. In rice, parasitism of the first generation of leafminers is low, but increases to 70 to 80% on the second and third generations. Normally a combination of parasites, predators, and high temperatures cause leafminer populations to drop rapidly by June.

Cultural Control

To reduce the potential for damage, level the field as accurately as possible and start the crop in 3 to 4 inches (7–10 cm) of water. Under these conditions, the rice will more likely emerge quickly and develop stout stems and erect leaves. Increase the water depth slowly after the leaves begin to grow upright. Similarly, where the crop is growing slowly in a cool season, lower the water to encourage more rapid growth. (See restrictions on water release in section on TREATMENT DECISIONS.) If the source of water is cold, such as some wells, you may want to establish a warming basin before the first seeded check.

Organically Acceptable Methods

Biological and cultural controls are organically acceptable methods.

MONITORING

Begin monitoring 2 to 4 weeks after planting, just after most of the rice plants have emerged from beneath the water and the leaves are lying on the water surface. Use a monitoring ring or floating plastic tubing 1-square-foot in diameter. Take ten, 1-square-foot samples in a transect of the field or field. Check the plants within the ring for unhatched leafminer eggs on upper leaf surfaces. Unhatched eggs are opaque, while hatched eggs are clear and flat. Also check for larvae of all instars; second and third instar larvae are the easiest to detect because you can feel the swelling they cause in the leaf.

Treatment Decisions

The following treatment guidelines are for fields seeded at 150 pounds per acre:

If the average plant stand is 25 or more plants per square foot and an average of 20% or more of the plants are infested, lower the water level and apply an insecticide. If the infestation level is 5 to 19%, lower the water and sample again in 4 days. If infestation levels do not increase and the plant stand remains at 25 or more, no treatment is needed.

If the average plant stand is less than 25 emerged plants per square foot and the infestation level is 10% or higher, lower the water level and use a recommended insecticide. If the infestation level is less than 10%, lower the water level and sample again in 4 days. If the infestation level stays this low, treatment will not be required. When most of the leaves of the rice plants are upright, the rice leafminer will no longer cause economic losses. Consider prevailing weather conditions in cases where the need to treat is not clear-cut. Cool growing conditions may favor leafminer damage.

Any release of the water is dependent upon what pesticide residues may be in the water and the time restrictions for holding the water in the paddies. Stopping the water flow into the paddies may allow an adequate reduction in the water level as a result of percolation and evaporation.

No treatments are required after leaves start growing upright above the water.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A. MALATHION (Malathion 8 Spray)	1.25 pt.	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Check with county agriculture commissioner for holding period and other restrictions following the use of this material. Do not apply within 15 days before or after application of the herbicide propanil. Do not spray over canals or laterals.			

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

RICE SEED MIDGES (10/15)

Scientific Names: *Cricotopus sylvestris*, *Paralauterborniella subcincta*, *Paratanytarsus* spp.

DESCRIPTION OF THE PESTS

Midges are the most common group of insects in rice fields. Over 30 species have been found in California rice fields, but comparatively few species are associated with seed and seedling injury. Adult midges swarm in small clouds over rice fields and other bodies of water in spring. They resemble very small mosquitoes but do not bite.

Females deposit their eggs in masses or strings, generally on open water. Eggs hatch in 1 or 2 days and larvae form silken tubes on vegetation or the soil. The tubes are brown in color and have bits of debris, diatoms, and algae adhering to them. The larvae may be white, green, or reddish in color. Larvae feed on the material adhering to their tubes and forage from the tubes, which serve as their retreat. The larvae go through 4 instars in 7 to 10 days in spring; the 3rd and 4th instars (0.16 to 0.24 inch or 4 to 6 mm long) are the most damaging to rice. Rice seed midges pupate in the tubes, complete development, and come to the water surface where the adult emerges. Three to four generations can occur each growing season, but only the first two are of economic concern to rice growers.

DAMAGE

Injury to rice is limited to germinating seeds and very young seedlings. Midge larvae feed on the emerging shoot, leaves, roots, or may hollow out the embryo and kill the plant. Once the seedling is several inches long, it can usually outgrow the feeding of midge larvae, even though irregular holes may be eaten in the leaf. Midge larvae may also feed on floating leaves, causing small holes that extend completely through the leaves. Again, injury to these older leaves is not of economic concern if other leaves are upright.

While midge larvae often eat the inside out of the seed, leaving it hollow, tadpole shrimp never cause this kind of injury. Tadpole shrimp and seed midge injury to the leaves and roots may be similar but the chewed areas caused by tadpole shrimp will be larger and more irregular because of the larger size of the shrimp mandibles. If the injury is caused by midges, the midge larva and tube are often still on the plant at the time of examination. If the injury is several days old, secondary organisms may invade the plant tissue, and the pest that caused the injury may be difficult to associate with the injury.

MANAGEMENT

The primary management strategy for controlling rice seed midges is draining fields. No chemicals are available for controlling this pest in rice.

Cultural Control

Seeding should be done as soon as possible after flooding, preferably within 2 days of initial flooding: any delay will expose germinating seed to older and larger numbers of midge larvae. In large fields that take longer than a few days to flood, seed parts of the field in sequence as they fill with water. Rapid root and shoot growth will reduce the period of time that the rice is susceptible to damage by midge larvae.

If monitoring during the first sample period (5 to 7 days after flooding) indicates action is needed, drain the field and reflood after a brief 3- to 4-day drying period. The length of the drying period depends on weather conditions and the time it takes to reflood. If the stand is unacceptably low, consider reseeding. Although reseeding fields with serious stand losses has had mixed results, if done early enough, it may be successful. As the time between original planting and reseeding increases, chances of reseeding success decrease.

If monitoring during the second sample period (8 to 14 days after flooding) indicates action is needed, the field can be drained or the water lowered until it is barely covering the soil. This will discourage feeding and encourage rapid rice growth.

The decision to drain must be made carefully because the potential increase in weed problems, herbicide and insecticide residue problems relating to drainage water, loss of fertilizer, and irrigation costs may outweigh the benefits for midge reduction.

Organically Acceptable Methods

Draining fields, as described above, is an organically acceptable management method.

MONITORING

Monitor for midge injury at the same time and with the same sampling devise used for tadpole shrimp. Examine each injured seedling or seed with a hand lens for chewing marks and the presence of midge larvae and tubes. Because the distribution of midge larvae and their injury may be irregular throughout a field, examine each field's basin.

Take the first sample 5 to 7 days after flooding begins. If you find less than 30 healthy seedlings per square foot and midge injury is evident, action should be taken. If more than 30 healthy seedlings per square foot are found, take a second sample 8 to 14 days after flooding. Check roots and shoots for damage. Generally, injury by midges at this time does not kill rooted plants. If the plant stand is below 25 plants per square foot and midge injury is still present, cultural action can be taken.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A. CLOTHIANIDIN (Belay) MODE-OF-ACTION GROUP NUMBER[1]: 4A	4.5 fl oz	12	NA

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

NA Not applicable

RICE WATER WEEVIL (10/15)

Scientific Name: *Lissorhoptrus oryzophilus*

DESCRIPTION OF THE PEST

The rice water weevil adult (about 0.125 inch or 4 mm long) has a prominent beak and is gray with a dark marking on its back from the base of its head to the middle of its wing covers. It is distributed throughout the Sacramento Valley, the upper San Joaquin Valley, and central San Joaquin Valley (Merced County). It overwinters as an adult at the base of grass clumps, in weedy debris on levees and ditch banks, or in soil crevices.

When daytime temperatures rise above 70°F (21°C) in late winter or early spring, rice water weevil adults begin feeding on grasses to build up their wing muscles. On calm, warm evenings (sunset to midnight), they fly in search of plant hosts growing in water. They are attracted to flooded rice fields and begin feeding on emerged rice or grasses in water along the levee banks. Longitudinal scars on the upper leaf surface indicate their presence in the field, if they are not directly observed.

No males occur in California and females reproduce without mating. After arriving in a field and feeding for a few days, they lay their eggs singly under water in the leaf sheath tissue above the plant crown. One female may lay over 200 elongated eggs (0.03 inch or less than 1 mm long) over a period of several weeks. The adults that initially infest a field prefer to feed and lay their eggs in areas of the field adjacent to the levee margins.

About 7 days after being laid, the eggs hatch. Small larvae mine the leaf sheath for about a day and then move to the soil to feed on the roots, where they stay through four larval instars. The legless larvae are milky white with light brown heads and have spinelike projections on their backs to pierce the roots and obtain oxygen. When their growth is completed, larvae pupate in mud-coated cocoons that they attach to the roots of rice, sedges, or various grasses.

Adults emerge from the pupal cells from July until September. They feed on rice leaves, but by this time most plants are growing vigorously and are not adversely affected by this late adult feeding. A few of these adults will lay eggs in July or August but most enter a resting stage called diapause. They fly to overwintering sites and remain at the base of plants, particularly perennial grasses, or debris through the winter.

The life cycle from egg to adult takes about 78 days in the laboratory at 73°F (23°C) with approximately 7 days in the egg stage, 50 days as larvae, and 21 days for pupation. The minimum time for development in the field is about 60 to 65 days.

DAMAGE

Rice water weevil is the most economically damaging of the invertebrate pests found in California. Root pruning by larvae is the major cause of reduced yields. Plants with damaged roots may become stunted and lose yield through reduction of tillers and panicles or because maturity is delayed. Reduced tillering and slower growth also allow weeds to become better established. The heaviest infestations and most serious damage can be expected to occur between late May and July within 15 to 20 feet of the margins of the fields and levees, where weevils are concentrated; moderate damage can occur in areas 20 to 35 feet from levees.

Adult feeding appears as linear slits of varying length on the upper surface of the leaves but generally does not cause economic losses. High populations of adults feeding on young rice seedlings just as they emerge through shallow water may kill some seedlings, but such injury is uncommon.

MANAGEMENT

Management of rice water weevil may be enhanced by weed control in areas around the rice field, drill seeding, and winter flooding, depending upon current management strategies for other pests. In fields with chronic, damaging populations of rice water weevil, a preventive treatment may be advisable with application limited to the field edges.

Cultural Control

Rice water weevil adults have shown a preference in California for the areas adjacent to levees and field edges during the critical period of infestation at the beginning of the season. Large, laser-leveled fields generally have less land per acre associated with levees and field edges and, therefore, large fields will have less area per acre subject to infestation.

Removing weedy vegetation on the levees in spring near the time of seeding can reduce rice water weevil infestations in fields and subsequent larval populations.

Drill seeding involves seeding the dry rice field, irrigating the soil to germinate the seed, and keeping the soil moist for 6 to 8 weeks, at which time the field is then flooded. By the time the field is flooded, rice plants are more tolerant to rice water weevil injury. This method of control reduces or eliminates exposure of susceptible plants to weevil populations but may not compatible with current weed management strategies.

Winter flooding of the field to enhance straw breakdown and provide waterfowl habitat can help with weevil control and reduce populations by about 50%.

Aquatic weeds are strong competitors of rice for nutrients and space, particularly during the tillering stage. Because the rice water weevil larvae prune roots and reduce tillering, it is particularly important to have early and effective weed control to maximize recovery from water weevil injury.

Organically Acceptable Methods

Cultural control methods including weed control and increasing field size are acceptable for use on organically certified rice.

Monitoring and Treatment Decisions

Treatment decisions for rice water weevil are primarily based on past history of a particular field, proximity to weevil overwintering sites (ditch banks, riparian areas, weedy canal banks, etc.) and economics. A new sampling method has been developed to aid in decision-making for post-flood insecticide applications. A floating barrier trap can be used and placed in fields immediately after flooding. If one rice water weevil adult per trap per day is collected during the first 7 days after flooding, that is indicative that damaging larval populations will likely develop and that a post-flood insecticide application should be considered. After the first 7 days after flooding and especially after seedling establishment, the trap does not efficiently sample adults and should not be used.

Lambda-cyhalothrin (Warrior), zeta-cypermethrin (Mustang), and diflubenzuron (Dimilin) are foliar treatments applied after flooding; these products control rice water weevil adults by disrupting their life cycle but have no toxicity against the weevil larvae, which is the primary damaging stage. Warrior and Mustang work by killing the adults, therefore reducing the number of eggs deposited and the resulting larval population. Rice plants are protected by the reduction of larval populations. Dimilin functions by sterilizing adult females, causing them to lay nonviable eggs, thus reducing the larval populations. It also is toxic to newly laid eggs, i.e., those that are less than 4 days old.

Lambda-cyhalothrin (Warrior) is also registered for a preflood application. In areas that have a history of rice water weevil infestations, this application should be considered. Applications can be made within 5 days of flooding and light incorporation is recommended to improve efficacy.

Because there is only one generation a year, timing is critical with these products. If they are applied too late, the eggs and larvae may already be present and the product will have little effect. Also, they are fairly short-lived products in water; if they are applied too early, they will dissipate before the adults are present in the field and have minimal effect.

Research has shown that applications of these products to only the 30 to 50 feet adjacent to the levees can provide acceptable rice water weevil control in most conditions. This is the area with the most significant rice water weevil infestation, and the insecticide applied only to this area persists in an adequate concentration long enough to affect the adult weevils.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A. CLOTHIANIDIN (Belay)	4.5 fl oz	12	NA

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: May be applied preflood or post-flood at 1–3 leaf stage with majority of plants in the second-leaf stage. Best control results of rice water weevil larvae have been seen with the post-flood application.			
B. LAMBDA-CYHALOTHRIN* (Warrior II with Zeon)	1.6–2.56 oz	24	21
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid that kills adult weevils for about 7 days and kills larvae as they hatch from eggs; can also be applied preflood. Apply at 1–3 leaf stage with majority of plants in the second leaf stage. Can be used safely when propanil products are being used for weed control. Do not release floodwater within 7 days of an application. See label for other restrictions.			
C. ZETA-CYPERMETHRIN* (Mustang)	3.4–4.3 oz	12	14
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid that kills adult weevils for about 7 days and kills larvae as they hatch from eggs. Make applications at least 7 days apart and do not release flood water within 7 days of application. Do not apply more than 1.1 pt (0.2 lb a.i.)/acre per season.			
D. DIFLUBENZURON* (Dimilin 2L)	8–16 fl oz	12	80
MODE-OF-ACTION GROUP NUMBER[1]: 15 COMMENTS: An insect growth regulator; sterilizes adult females for about 7 days and kills 1-3 day old eggs already in the plant. Apply 2–5 days after rice emerges above water (i.e., 2–3 leaf stage). Can be used safely when propanil products are being used for weed control. Do not apply if flooding is in progress; activity will be reduced. This material is water active so the entire field must be treated. Do not disturb flooded area after application for at least 7 days. Treated water should be held for at least 14 days. Do not use on wild rice or near crayfish aquaculture. See label for other restrictions.			

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

NA Not applicable

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

TADPOLE SHRIMP (10/15)

Scientific Name: *Triops longicaudatus*

DESCRIPTION OF THE PEST

Although they are crustaceans, tadpole shrimp resemble tadpoles in size, shape, color, and mobility. Tadpole shrimp have about 35 body segments, and all but the last six or seven have pairs of leaflike, gill-bearing appendages. A thin, olive-brown shield covers the front section of the body, and two long tails extend from the last segment. Two long, jointed appendages resembling antennae extend from below the well-developed chewing mandibles.

Adults deposit eggs singly on soil or on plants at the bottom of the field. They are highly resistant to drying and remain viable for several years in unflooded soil. Most of the eggs hatch 1 to 3 days after spring flooding of the rice fields, but hatching may continue for 1 to 2 weeks. The young develop rapidly by a series of molts and resemble the adults in less than 24 hours. They feed on a variety of small animals and plants commensurate with their size as they grow and molt. The somewhat transparent molt skins may be mistaken for dead shrimp. The first instar larva is about 0.2 inch (5 mm) long. Egg pouches are first noted when shrimp are about 0.63 inch (16 mm) long, and by 3 weeks old the shrimp may be 1 inch (2.5 cm) long. At maturity, tadpole shrimp are about 1.5 inches long. Masses of red-orange eggs occur in 7 to 10 days from hatching in two brood pouches on the appendages of the 11th segment at the lower margin of the shield.

DAMAGE

Tadpole shrimp cause losses in seedling rice stands in two ways. First, they may chew off the coleoptile, roots, and leaves of the seedling, and uproot seedlings with their digging and feeding activity, all of which may kill the plants. Second, their digging activities associated with egg laying muddy the water, reducing light penetration and thereby slow the growth of the submerged seedlings. Tadpole shrimp cause no injury to rice once leaves have reached the water surface and roots are well established in the soil.

MANAGEMENT

Management of tadpole shrimp involves rapid seeding of the field after flooding and monitoring twice within the first 2 weeks following flooding to determine the need for chemical treatment. As an alternative, some population reduction can be obtained by flooding and draining the field before flooding for seeding.

Cultural Control

Most tadpole shrimp eggs hatch within 2 days after contact with water. The longer the time between hatching of the eggs and planting, the larger the size of the shrimp and the greater the potential for plant injury. Flood the field as fast as possible, and seed as soon as possible after flooding has been initiated. In very large fields that take more than a few days to flood, you may want to seed basins (checks) in sequence as they fill with water. Rice stands that have been reduced by shrimp feeding can be reseeded but generally a good stand of rice is difficult to establish in this manner.

Flooding and draining the field before planting will kill hatched tadpole shrimp through desiccation and are alternatives to chemical control. Do not drain the field until 4 to 5 days after initial flood so the maximum egg hatch can occur. The draining time will vary based on soil type and weather but should continue for at least 24 hours after all standing water is gone. Shrimp will gather in standing water in low areas and will reinfest the field if the drain period is too short. Reflooding may result in some shrimp from previously unhatched eggs, but they would be in noneconomic numbers and less likely to damage the older, firmer rooted seedlings. Any soil cultivation following the drain period may bring viable, unhatched shrimp eggs to the soil surface for possible infestation upon reflooding, however.

A decision to drain must take into account possible negative aspects such as fertilizer loss, encouragement of weeds, or interruption of weed control procedures, interruption of pesticide holding requirements, and the economics of irrigation.

Organically Acceptable Methods

Draining, as described under cultural controls, and applications of copper sulfate are organically acceptable methods.

MONITORING

Check all your fields during seedling development, but give special attention to those that had significant populations of tadpole shrimp last year. Even though infestations may have been localized in previous years, monitor all quadrants of the field because the shrimp can occur well beyond previously observed boundaries. Masses of wind-blown cut leaves and floating seedlings along the levees combined with muddy water are good evidence of tadpole shrimp activity. Check for shrimp and floating shrimp molt skins to confirm the pest, because crayfish and seed midges cause similar damage. If the water is clear, you can usually see the shrimp on the bottom although they may be small. If the water is murky or muddy, you may still see the shrimp as they come to the surface but cool temperatures may slow their activity. A fish seine (1/8-inch mesh) pulled along the bottom of the field will reveal their presence or absence.

The action threshold is determined by counting numbers of seedlings at various stages of development. Take samples twice during seedling development: at 5 to 7 days after flooding is initiated and again 3 days to a week later. Use a metal or plastic cylinder or square with open ends that encloses 1 square foot and with sides higher than the water depth, to count the plant stand. Place it in the water gently so the area to be observed remains clear. If the water is murky because of wind and wave action, you may have to wait a day or two to allow it to clear. An alternative to waiting is to view the seedlings through a clear glass or plastic container or jar held within the sampling device. Hold the viewing device open end up and push it down into the cloudy water until you can see the bottom of the field and move the jar around to see the seedlings. Take 10 samples across the check on each sampling date. Take 20 samples if your checks are large. The treatment guidelines below are based on a seeding rate of 150 pound per acre.

Treatment Decisions

Take the first sample 5 to 7 days after flooding begins. Treat if tadpole shrimp or their molted skins are present and less than 30 healthy seedlings per square foot are found, and there is damage due to shrimp feeding.

Take the second sample 8 to 14 days after flooding. An average of 25 or more healthy seedlings per square foot at this time should provide a good stand. Treat if less than 25 healthy seedlings are found and evidence of shrimp is present in the monitoring area. If 25 or more healthy seedlings are found but there is also evidence of tadpole shrimp activity, repeat the sampling procedure every 2 to 3 days until rice plants emerge above the water surface. Treat if the average number of seedlings drops below 25 plants.

If muddy water does not allow an adequate visual inspection of the plant stand after 8 days, treatment decisions must be based on the presence of shrimp and shed skins, and observations of chewed shoot tips or roots, or uprooted floating seedlings.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.*** *When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.*			
A. LAMBDA-CYHALOTHRIN*			
(Warrior II with Zeon)	1.6–2.56 oz	24	21
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Can be used safely when propanil products are being used for weed control. Do not release floodwater within 7 days of an application. See label for other restrictions.			
B. COPPER SULFATE PENTAHYDRATE#	5–10 lb	See label	See label
COMMENTS: Use smallest size crystal. The minimum rate is only effective if water is shallow and being held. Not all copper compounds are approved for use in organic production; be sure to check individual products.			
C. CARBARYL*			
(Sevin 4F)	1.5 qt	12	14
(Sevin XLR Plus)	1.5 qt	12	14
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not apply 15 days before or after the application of propanil. Rates for California only.			

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

UPDATED 10/15

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

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

\# Acceptable for organically grown produce.

Diseases

(Section reviewed 4/04)

AGGREGATE SHEATH SPOT OF RICE (10/15)

Pathogen: *Rhizoctonia oryzae-sativae*

SYMPTOMS

Aggregate sheath spot lesions first appear on the lower leaf sheaths at the water line during the tillering stage. Lesions are circular to elliptical with gray-green to straw-colored centers surrounded by distinct brown margins. Frequently, additional margins form around the initial lesion, producing a series of concentric bands. A strip of light-colored necrotic cells runs down the lesion center. Later in the season, secondary infections frequently occur well above the water line.

COMMENTS ON THE DISEASE

The disease cycles of aggregate sheath spot and stem rot are similar in a number of ways. *Rhizoctonia oryzae-sativae* produces sclerotia that are resistant to adverse conditions and allow the fungus to overwinter. In spring and early summer, these overwintering bodies float on the field water surface and are the source of initial infections that occur at the water line. Unlike the sclerotia of the stem rot fungus, these sclerotia are brown, rectangular to irregularly globose in shape and are much larger in size. Also, unlike stem rot, secondary leaf sheath infections progress up the stem and, under favorable conditions, may reach as high as the panicle. On the sheath, lesions often coalesce and may cover the entire leaf sheath. Leaves of diseased sheaths turn bright yellow and then die. Under favorable conditions (high humidity or rain), the disease can spread to the flag leaf and panicle rachises, killing entire tillers. Later in the season, the fungus begins to produce new sclerotia on or in diseased tissue. These sclerotia overwinter in crop residue or in soil.

Aggregate sheath spot of rice can also colonize the culm, where it may cause a culm rot, but this aspect of the disease is rare in California.

Aggregate sheath spot is similar to but distinct from sheath blight of rice caused by *Rhizoctonia solani*, a serious disease of rice in the southern U.S. and other parts of the world. Sheath blight has not been observed in California.

MANAGEMENT

The most effective way to manage aggregate sheath spot is to limit the carryover inoculum from one year to the next by removing or destroying crop residues. Treatments may be necessary if monitoring indicates leaf lesions are approaching the flag leaf sheath.

Cultural Control

Disease cycles of stem rot and aggregate sheath spot are similar and they are managed with similar methods, i.e., use of the most resistant varieties available and cultural practices that reduce carryover inoculum. All public rice varieties currently grown in California are susceptible to aggregate sheath spot of rice to some degree.

Burning of crop residues after harvest provides the most effective control for this disease. Complete removal of infected crop residues also minimizes carryover inoculum levels. Moldboard plowing, crop rotation, or fallowing should also minimize carryover inoculum. Avoid dense rice stands as they may enhance disease development.

Organically Acceptable Control Methods

All the cultural controls discussed above are organically acceptable.

Monitoring and Treatment Decisions

Monitoring is essential in making treatment decisions for aggregate sheath spot. After tillering, examine tillers on a weekly basis in several locations throughout the field for the presence and progress of aggregate sheath spot lesions. If lesions have begun to elongate and are approaching the flag leaf sheath or the leaf sheath below the flag leaf, a treatment may be justified. Treat before lesions spread to the leaf sheath on the leaf below the flag leaf. When making a treatment decision, also consider the crop growth stage. For example, lesions that are approaching the flag leaf before boot are generally considered to be a greater risk than lesions approaching the flag leaf after flowering.

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

UPDATED 10/15

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

A. AZOXYSTROBIN
(Quadris) 12.3–15.4 fl oz 4 28
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: A protectant fungicide. Follow label directions. Limited studies have shown a single application at the lowest labeled rate to be effective, but results may vary under different conditions. Under heavy disease pressure and conditions favorable for disease development, a second application may be applied. Water holding period is 14 days.

B. AZOXYSTROBIN + PROPICONAZOLE
(Quilt Xcel) 14–27 fl oz 12 35
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Demethylation inhibitor (3)

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

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BAKANAE (10/15)

Pathogen: *Gibberella fujikuroi* (*Fusarium moniliforme*)

SYMPTOMS

Symptoms of bakanae first appear about a month after planting. Infected seedlings appear to be taller, more slender, and slightly chlorotic when compared to healthy seedlings. The rapid elongation of infected plants is caused by the pathogen's production of the plant hormone, gibberellin. Plants with bakanae are often visible arching above healthy rice plants; infected plants senesce early and eventually die before reaching maturity. If they do survive to heading, they produce mostly empty panicles.

COMMENTS ON THE DISEASE

Bakanae is one of the oldest known diseases of rice in Asia but has only been observed in California rice since 1999 and now occurs in all California rice-growing regions. While very damaging in Asia, the extent to which bakanae may effect California rice production is unknown.

As diseased plants senesce and die, mycelium of the fungus may emerge from the nodes and may be visible above the water level. After the water is drained, the fungus sporulates profusely on the stems of diseased plants. The sporulation appears as a cottony mass and contaminates healthy seed during harvest. The bakanae pathogen overwinters as spores on the coat of infested seeds. It can also overwinter in the soil and plant residue. However, infested seed is the most important source of inoculum.

MANAGEMENT

The most effective means of control for this disease is the use of noninfested seed. Also, when possible, burning plant residues with known infection in fall may help limit the disease. Research is under way to identify effective seed treatments. Field trials indicate that a seed treatment with sodium hypochlorite (Ultra Clorox Germicidal Bleach) is effective at reducing the incidence of this disease. Using a thoroughly premixed solution of 5 gallons of bleach to 100 gallons of water, seed is soaked for 2 hours, then drained and soaked in fresh water.

Common name (example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the and least likely to cause resistance are at the top of the table****. When choosing a pesticide, consider information relating to the pesticide's propertiesand application timing , honey bees, and environmental impact. Always read the label of the product being used.*			
A. SODIUM HYPOCHLORITE (Ultra Clorox)	2.5% solution (2.5 gallons in 97.5 gallons water)	24	NA
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Unknown COMMENTS: Preplant rice seed treatment. Replace water with 2.5% Ultra Clorox solution during the seed soaking period. Drain and seed within 12–24 hours of draining, as fungal inoculum may increase on seed being held in trailers about 24 hours after draining.			

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

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NA Not applicable

KERNEL SMUT (4/04)

Pathogen: *Tilletia barclayana*

SYMPTOMS

Kernel smut appears as a black mass of chlamydospores that replace all or part of individual kernels near or at maturity. Usually only a small number of kernels on each panicle are infected. Completely smutted kernels may be slightly swollen while others may break open exposing the dark spores. These black spores make the disease easy to recognize. If the disease is severe, a dark cloud of spores may be observed coming from the harvester during harvest.

COMMENTS ON THE DISEASE

Chlamydospores liberated during harvest fall to the soil where they overwinter. The fungus can also overwinter in or on seeds. In spring as the fields are flooded, chlamydospores float, germinate, and produce other spore and mycelial stages. At flowering (heading), secondary airborne spores (sporidia) infect individual florets or kernels.

Kernel smut is generally considered a minor disease of rice. In southern U.S. rice growing areas, it is more prevalent during rainy years and in areas of fields receiving high rates of nitrogen fertilizer. Disease surveys have shown short and medium grain varieties to have lower incidence rates for kernel smut than long grain varieties. Long grain rice varieties may be more susceptible to kernel smut because their florets are open wider and longer during flowering. Because the fungus is widespread in California's rice growing areas, no effort has been made to restrict infested seed lots.

MANAGEMENT

Cultural practices are the primary means of managing kernel smut. Chemicals for controlling this disease are not registered for use on rice in California at this time.

Cultural Control

Avoid excessive rates of nitrogen fertilizer. Plant short or medium grain varieties in fields with kernel smut history. Plant certified rice seed.

Organically Acceptable Control Methods

All the cultural controls discussed above are organically acceptable.

RICE BLAST (10/15)

Pathogen: *Pyricularia grisea*

SYMPTOMS

The rice blast fungus may infect and produce lesions on most of the shoot but usually not the leaf sheath. From the seedling stage through plant maturity, rice blast progresses through several phases starting with leaf blast, followed by collar, panicle and node blast.

Leaf Symptoms

Lesions that occur on the leaf are usually diamond-shaped with a gray or white center and brown or reddish brown border and are 0.39 to 0.58 inch (1.0–1.5 cm) long and 0.12 - 0.2 inch (0.3-0.5 cm) wide. Newly formed lesions may have a white or grey-green center and a darker green border. Their shape, color, and size can vary depending on varietal resistance, age of the plant, and lesion age. Leaf blast may sometimes cause the complete death of young plants up to the tillering stage. Leaf blast usually increases early in the season then declines late in the season as leaves become less susceptible.

Leaf Collar Symptoms

Infection at the junction of the leaf blade and sheath results in the typical brown "collar rot" symptom. A severe collar infection may cause the leaf to die completely.

Node Symptoms

Stem nodes may be attacked as the plant approaches maturity, causing the complete death of the stem above the infection. Diseased nodes are brown or black

Panicle and Grain Symptoms

Infections just below the panicle, usually at the neck node, cause a "neck rot" or "rotten neck blast" symptom that can be very injurious to the crop. If neck rot occurs early, the entire panicle may die prematurely, leaving it white and completely blank. Later infections may cause incomplete grain filling and poor milling quality. Other parts of the panicle including panicle branches and glumes may also be infected. Panicle lesions are usually brown, but may also be black.

COMMENTS ON THE DISEASE

Rice blast was first identified on California rice in 1996. The disease is favored by long periods of free moisture, high humidity, little or no wind at night, and night temperatures between 63 and 73°F. Leaf wetness from dew or other sources is required for infection. The optimum day time temperature for spore germination, lesion formation, and sporulation is 77 to 82°F. Sporulation is also greatest when relative humidity is above 93%.

Shortly after the fungus infects and produces a lesion on rice, fungal strands called conidiophores grow out of the diseased rice tissue and produce spores called conidia. These conidia are dispersed in the air and under favorable conditions may cause new infections. When conditions are favorable, a single disease cycle can be completed in about a week. In addition, a single lesion can produce hundreds to thousands of spores in one night and may produce them for more than 20 days. Under favorable moisture and temperature conditions, the fungus can go through many disease cycles and produce a tremendous load of spores by the end of the season.

The blast fungus can overwinter from one season to the next on diseased crop residue and seed. Weeds have been shown to be alternate hosts for the disease in the greenhouse, but their role in nature is unclear. Of the overwintering sources, rice straw and stubble are probably the most important.

MANAGEMENT

Rice blast management in California requires implementing a variety of cultural practices (destruction of infested residue, use of noninfested seed, water seeding, continuous flooding, and avoiding excess nitrogen). Environmental conditions in California appear to be permissive for blast development but are usually not conducive. In other areas of the world where conditions are not conducive, the disease is most easily controlled by resistant cultivars, but resistant cultivars are not yet available in California. Fungicides are available, but are only needed when unusually wet conditions occur during the California growing season.

Cultural Control

Blast is favored by excessive nitrogen fertilization, aerobic soils, and drought stress. High nitrogen rates and nitrate nitrogen increase rice susceptibility to the disease. Extended drain periods may also encourage the disease by aerating the soil, by converting ammonium to nitrate, and by causing drought stress to rice.

Use proper seed sampling and testing to identify and avoid the use of blast-infested seed in areas where blast is not a problem. This may help limit the introduction of the disease into noninfested areas.

Water seeding is recommended to reduce or eliminate disease transmission from seed to seedlings. Drill seeding is not recommended because it may allow seed transmission, nitrate formation, and result in drought stress.

Continuous flooding is recommended to limit blast development. Avoid field drainage, especially for extended periods because it allows the formation of nitrate and may cause drought stress. Some studies in other areas suggest that shallow water is more favorable to blast development than deeper water.

Varietal Susceptibility

California varieties are susceptible to blast, and M-201 appears to be the most susceptible followed by M-104 and M-205. Of the widely grown varieties, M-202 appears to be more tolerant than others and exhibits some field resistance to leaf blast. Blast has been observed on M-201, M-202, M-204, M-205, M-103, M-104, S-102, L-204, Calmochi-101, and several proprietary varieties.

Monitoring and Treatment Decisions

Monitor to determine the need for treatments. Throughout the season, examine plants in several locations throughout the field for the presence of leaf lesions; intensify monitoring as plants approach the boot stage. If blast lesions are present and increasing just before the boot stage, a treatment may be justified. When making a treatment decision, consider disease progress, crop growth stage, environmental conditions, and rice variety. For example, there is a greater risk of neck and panicle blast infections occurring when growing one of the more susceptible cultivars and long periods of leaf wetness and warm night temperatures occur. Use a protectant fungicide so that the panicles is protected as it emerges from the boots. Because rice blast is a multiple cycle disease, fungicide applications to control leaf blast early in the season are generally ineffective in reducing the incidence of neck blast and yield losses.

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

UPDATED 10/15

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

A. AZOXYSTROBIN
(Quadris) — 12.3–15.4 fl oz — 4 — 28
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Follow label directions. Limited studies have shown a single application at the lowest labeled rate to be effective, but results may vary under different conditions. Can be applied as a preventive treatment for blast control and applied before favorable conditions for blast development. For panicle blast, application can be made at mid-boot to boot-split, but before full head emergence. Under heavy disease pressure and conditions favorable for disease development, use maximum label rates; a second application may be applied when panicles are about 60–90% emerged from the boot (7–14 days later). Water holding period is 14 days.

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

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SEED ROT AND SEEDLING DISEASES (10/15)

Pathogens: *Achlya klebsiana* and *Pythium* spp.

SYMPTOMS

Seed rot and seedling diseases often appear within a few days of planting. Whitish outgrowths of fungal mycelium emerge from cracks in the seed glumes or from the collar of the infected seedling's plumule. After a few days, the fungal mycelium resembles a halo that radiates from the infection point on the seed or seedling. Various algae colonize the fungal growth turning it green. In some cases the infected seed appears within a dark circular spot on the soil surface. This too may be the result of algae growth, but is most probably caused by secondary invasion of the seed and fungus by various aquatic bacteria. Early infection of germinating seeds, especially when temperatures are cool, will often result in seed rot or seedling mortality.

If seedlings produce primary leaves and roots before infection occurs, they usually survive but are typically stunted. Leaves and sheaths become yellow or chlorotic, and further development is retarded. The typical fungal halo is usually evident. If infection occurs after seedlings are well established, there is generally little apparent effect.

COMMENTS ON THE DISEASE

The disease, although prevalent throughout the rice-producing areas of California, is generally more severe when cool temperatures, which are unfavorable for rice growth, occur at or shortly after planting time. If ideal conditions for development of seed rot and seedling diseases occur, water-sown rice often is severely infected within a few days after seeding, resulting in reduced plant stands or reduced seedling vigor.

MANAGEMENT

Seed treatments with fungicides provide protection against seed rot and seedling diseases, especially if seed is planted early or if environmental conditions are unfavorable to germination and seedling growth. Uneven stands caused by seed rot and seedling diseases can be partly compensated for by increasing seeding rates.

Cultural Control

Plant high quality rice seed (preferably certified seed) with 85% germination or more and a bushel weight of 44 pounds or more. Plant when water temperatures are favorable for rice seed germination and growth of rice seedlings (preferably above 70°F or 21°C). Maintain a uniform water depth of about 4 inches or 10 cm; this will also improve germination, rice stand establishment, and tillering. If the field has had severe problems in the past with seedling diseases or temperatures are expected to be cool at or shortly after planting, an increased seeding rate may be advisable.

Organically Acceptable Control Methods

Recommended cultural controls are organically acceptable.

Treatment Decisions

The benefits from fungicide seed treatment in water-sown rice are most obvious during the early planting season when environmental conditions are often unfavorable for germination and seedling growth. Chemical seed treatment increases the percent stand establishment, thus reducing the need to replant and helping to establish uniform rice stands.

Common name (example trade name)	Amount to use per 100 lb seed	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the and least likely to cause resistance are at the top of the table****. When choosing a pesticide, consider information relating to the pesticide's propertiesand application timing , honey bees, and environmental impact. Always read the label of the product being used.*			
A. COPPER HYDROXIDE (Champ Formula 2)	2–4 fl oz	48	NA
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M1)			

Common name (example trade name)	Amount to use per 100 lb seed	REI‡ (hours)	PHI‡ (days)
UPDATED 10/15			
COMMENTS: Treat rice seed before soaking for water-sown rice. Follow label directions for disposal of soak water. Contact your farm advisor regarding specific recommendations for your area. Not all copper compounds are approved for use in organic production; be sure to check individual products.			

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

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NA Not applicable

STEM ROT OF RICE (10/15)

Pathogen: *Sclerotium oryzae*

SYMPTOMS

In water-sown rice, stem rot first appears during the tillering stage as small, black lesions on leaf sheaths at the water line. As the disease progresses, infected sheaths die and slough off. The infection may eventually penetrate the culm.

COMMENTS ON THE DISEASE

The fungus overwinters as small, black resting structures called sclerotia. Sclerotia can survive free in the soil, but are more often associated with infected rice plant residues remaining in the field after harvest. The following season, after the field is flooded, sclerotia float to the water surface and infect leaf sheaths of young rice plants at the waterline. New infections continue to occur throughout the growing season.

When the culm is infected, both grain quality and panicle size are reduced. When infection occurs very early in the season, tillers are either killed or fail to produce panicles; additional losses often result from increased lodging of infected plants. Yield losses from 6 to 24% have been measured in California.

MANAGEMENT

Manage stem rot by minimizing the carryover inoculum level (i.e., the number of viable sclerotia) and by using the most resistant varieties available. Surface-applied potassium fertilizer and winter flooding of rice fields are also reported to suppress rice stem rot development. While the protectant fungicide azoxystrobin (Quadris) is labeled for stem rot, data from research trials indicate the effect on disease incidence and severity have been negligible and that applications for this disease are not economically beneficial.

Cultural Control

Carry-over inoculum produced in residue from the previous crop infects the current year's crop and any practice that minimizes the amount of inoculum in the seed bed is beneficial in disease management. One method of reducing carryover inoculum is field burning of rice residue in fall following harvest. Field burning destroys existing sclerotia and residue upon which sclerotia form during late fall, winter, and spring. The level of carryover inoculum is determined by the completeness of the residue destruction. Another method that is as effective as field burning is cutting rice at ground level and removing the straw from the field in fall. Tillage practices, such as moldboard plowing, that bury sclerotia and prevent it from floating and infecting the plants at the waterline reduce inoculum levels. Again, the level of disease reduction is dependent on the effectiveness of the burying, which could be hindered by soil moisture conditions or a large volume of residue.

Fallowing fields for a year will reduce the number and viability of the sclerotia. If a fallow field is irrigated during summer, the crop residue degrades even faster, thus reducing the production of sclerotia.

In addition to managing inoculum levels, use the most resistant varieties available. All public rice varieties currently being grown in California are susceptible to stem rot to some degree. Average stem rot scores are included in the current list of characteristics of publicly developed rice varieties. Least susceptible of the widely grown varieties include M-205, M-206, and M-402. Most susceptible are M-103, M-104, M-202, M-204, M401, and S-102.

Stem rot incidence and severity increase as stand densities are increased; thus, avoid rice stands that are too dense. In research plots, rice stand densities of 10 to 12 established plants per square foot produced yields equal to stands ranging up to 34 plants per square foot. A seeding rate of 150 pounds per acre is recommended.

Excess rates of nitrogen fertilizer increase rice stem rot severity. Stem rot severity is lower on plants grown at minimum adequate levels of nitrogen. When growing rice at minimum adequate nitrogen levels, use rice tissue analysis, leaf color chart, or chlorophyll meter readings to monitor critical nitrogen levels during the growing season to determine any need for supplemental nitrogen.

The stem rot fungus may penetrate the plant directly or invade wounds. Practices that injure or stress rice plants (e.g., the use of phenoxy herbicides) have been shown to increase infection and disease development.

Organically Acceptable Control Methods

All the cultural practices discussed above are acceptable for organic growers.

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

UPDATED 10/15

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

A. AZOXYSTROBIN
(Quadris) 12.5–15.5 fl oz 4 28
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: A protectant fungicide. Follow label directions. Limited studies have shown a single application at the lowest labeled rate to be effective, but results may vary under different conditions. Under heavy disease pressure and conditions favorable for disease development, a second application may be applied. Water holding period is 14 days.

B. AZOXYSTROBIN + PROPICONAZOLE
(Quilt Xcel) 14–27 fl oz 12 35
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Demethylation Inhibitor (3)

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

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Weeds

(*Section reviewed 6/19)*

INTEGRATED WEED MANAGEMENT (6/19)

(Reviewed 6/19)

Successful weed management in the production of California rice is based on a combination of cultural and chemical control methods, including prevention, land preparation, crop rotation, tillage, fertilizer management, water management, and proper use of herbicides. Herbicide resistance is an increasing problem that has added considerable complexity to weed management. The components of an integrated weed program for a specific field are determined by the weed species present and their levels of infestation, weed resistance to herbicides, the water management system, and the capability to rotate to other crops or fallow.

PREVENTION

Prevention is an important part of rice weed control. Use certified seed, the cleaning of farm implements when moving from field to field, and the elimination of rice weeds growing on levees and roadsides.

LAND LEVELING

High and low areas and steep slopes within a flooded basin make it impossible to achieve a uniform water depth, resulting in uneven weed and rice plant growth. Leveling to more gradual slopes and eliminating unevenness within each basin greatly improve weed control. Laser leveling is an excellent tool for this purpose because of its high accuracy and precision. Global positioning system (GPS) guided land leveling is a newer technology that can create field maps in three dimensions, making land leveling even easier and more precise than laser leveling.

Choice of field grade and levee spacing is influenced by several factors. To create a desirable grade for optimum weed control and rice growth, allow variation of no more than 2 to 3 inches between shallow and deep areas of a basin and a maximum depth of 5 inches. This can be facilitated with a slope between levees of 0.25 feet or less. Although fields with near zero grades may improve weed control and rice stand establishment, they are more difficult to drain for postemergence herbicide applications.

CROP ROTATION

In fields that can be rotated to other crops, use rotation to greatly reduce the numbers and species of weeds that cannot be selectively controlled with herbicides and cultural practices in rice. Rotation crops to consider include tomato, safflower, or cereal crops. Non-flooded conditions, seedbank decay, and alternative herbicides that can be used in these rotation crops all contribute to reducing future weed infestations in rice.

In fields with severe infestations of perennial weeds with tubers, rhizomes, or large rootstocks (such as cattail, pondweed, Gregg's arrowhead, bulrush, or spikerush), consider a dry fallow rotation out of rice. Plow the rice field to a depth of 8 to 12 inches during the fallow season to expose underground stems of cattails and Gregg arrowhead, tubers of river bulrush, and winter buds of American pondweed; this can reduce the numbers of these perennial weeds as long as sufficient drying of the soil and reproductive plant parts is achieved in spring. Plowing to a depth of 8 to 12 inches combined with rotating to a non-irrigated crop (such as safflower) improves soil desiccation further. Avoid transfer of stems, tubers, and buds to clean fields by tillage equipment.

In fields that are suitable only for a rice crop, rotate water management methods to help control weed species resistant to herbicides normally used in rice production. For example, flood the field one year and the next, use dry seeding or stale seedbed techniques coupled with nonselective, preplant herbicides.

TILLAGE

With the advent of rice straw incorporation and winter flooding, the objectives of tillage have changed. Because the soil is wetter for longer periods, it is not possible to use tillage in fall to expose and dehydrate the rhizomes, tubers, and corms of perennial weeds unless a particularly heavily infested field is specifically targeted for dry tillage. Straw incorporation by wet rolling, and especially discing and plowing in fall, also incorporates weed seeds into the soil. This protects weed seeds from depredation by bird and small mammals. The exception to this is fall or spring plowing 6 to 8 inches deep, which buries weed seed below the germination zone and may substantially reduce weed numbers as well as the vigor of seedlings that do emerge. Although buried weed seed eventually declines in vigor and the ability to germinate, some species survive for a long time and may be brought to the surface by subsequent tillage operations.

Spring tillage destroys weed seedlings that have germinated before seedbed preparation. However, unless spring temperatures have been warm, only a small percentage of the total seed bank will have germinated. Nonetheless, it is essential to kill these weeds by working dry seedbeds and allowing the soil to dry out before flooding. Tilling wet soils may only transplant seedling weeds, which become severe competitors with the later-planted rice and are very difficult to control with herbicides.

Groove the rice seedbed with a heavy, ridged roller to produce a uniform corrugated seedbed that will protect young rice seedlings from wind and wave drift. While heavy rollers provide a more uniform seedbed, they may bring moisture to the surface in wet soils, thus increasing early weed establishment. If a rice roller is not used, make sure the final seedbed is free of large clods. Large clods exposed above the water are havens for the germination and emergence of grass weeds that later will be too large to control with herbicides. Use land-leveling equipment to eliminate high areas before rolling or other methods of seedbed preparation; this will assist in reducing clod size.

FERTILIZER MANAGEMENT

Inject or soil incorporate nitrogen and phosphate fertilizers 2 to 4 inches deep to increase their availability to the growing rice plant, reduce their availability to weed seedlings that germinate near the soil surface, and prevent nitrogen losses. Submerged aquatic weeds such as southern naiad (*Najas guadalupensis*), chara (*Chara* sp.), and algae grow more vigorously and may become well established when high rates of nitrogen and phosphorous are left on the soil surface. Avoid topdressing with nitrogen or phosphorous into the water before the rice canopy has covered the field surface, as this also encourages rapid growth of weeds.

Surface-applied triple superphosphate (TSP), a type of calcium phosphate fertilizer, can increase the number of sedge and broadleaf weeds, including smallflower umbrella sedge, blue-flowered ducksalad, redstem, ricefield bulrush, waterhyssop, and California arrowhead. Calcium alone can stimulate smallflower umbrella sedge germination but has no effect on ricefield bulrush germination, whereas phosphorus has no effect on stimulating either smallflower umbrella sedge or ricefield bulrush germination. Therefore, when applying calcium phosphate, consider incorporating preplant applications into the soil profile to reduce the emergence of certain (largely small-seeded) rice weeds.

WATER MANAGEMENT

Water management is the most important cultural factor for the successful control of many important rice weeds. Water that is too deep may impede stand establishment or result in water spillage; water that is too shallow may expose the soil surface and allow weed seed germination. During long water-holding periods, start with relatively deep water and allow it to recede to a desired depth (5 inches) rather than beginning at this level and adding water as needed.

Water management practices are an integral part of any rice weed management program and greatly influence the efficacy of many herbicides. In the past, fields were flooded continuously at a depth 4 to 8 inches to suppress weeds (e.g., grasses and smallflower umbrella sedge) and herbicides were applied into the water. However, as weeds developed resistance to many of the into-the-water herbicides, it has become necessary to use more foliar-active or contact herbicides that require the fields to be drained early season so the herbicides adequately cover the weed seedling. These fields must then be rapidly reflooded to prevent a new flush of weed seed germination.

Water Management and Herbicide Applications

The introduction of foliar-applied herbicides in rice has necessitated the need to manage water depth in relation to herbicide applications. Commonly used water management regimes in California include delayed pin-point flood (or just pin-point flood), the Leathers' method, and permanent flood.

Pin-point flood

Drain the field 2 to 4 weeks after sowing to facilitate early application of foliar herbicides. Water may be shut off and allowed to subside rather than drain. After the herbicide application, fields are reflooded to 4 to 6 inches and maintained. Another version of this practice is to lower water during the early tillering stage of rice to expose weeds to foliar herbicides. Quick removal of water at this time and replacement after spray application is important for good weed control. A prolonged drain period promotes weed growth; delayed reflooding reduces herbicide efficacy.

Leathers' method

Drain the field rapidly and completely immediately after sowing. Then leave the water off the field until the rice radicle penetrates the soil and anchors the seedling. Fields are left drained for 3 to 5 days, depending on temperature and growth of roots, and then rapidly reflooded after the rice seed has anchored in the soil. This method is generally used to promote early establishment of rice and where early-season, wind-caused wave action tends to dislodge and move germinating rice seed. This early drain can activate germination of a number of weed species at the same time.

Permanent flood

A water depth of 4 to 5 inches is established as soon as possible after sowing and maintained for the rest of the season to maintain steady pressure on weeds and optimize rice growth.

Effect of Water Depth on Weeds

Exceptionally shallow water (up to 2 inches) promotes the growth of all rice weeds and, in addition, may promote weeds normally found only in other annual crops. Intermittent draining, particularly early in the season, may allow weed seedlings to establish that would not have survived a continuous flood. Soil exposure to air as a result of draining increases the diffusion of oxygen into the soil profile, especially if the soil is allowed to dry. Increases in oxygen concentration initiates the germination of weed seeds and favors establishment and growth of most weeds. A permanent flood restricts light penetration and oxygen diffusion into the soil, thereby decreasing weed germination and growth.

Grasses

Watergrass (Echinochloa spp.), also known as barnyardgrass, is the most serious weed in continuously-flooded California rice. It is variable in form, and three distinct species occur in California rice fields: terrestrial barnyardgrass, early watergrass, and late watergrass.

Terrestrial barnyardgrass is the most widespread and easiest to control by floodwater. In fact, the California system of water-seeding rice was established to control this species. Maintaining water 4 inches (10 cm) deep still provides good control.

Early and late watergrasses will grow through 4-inch deep water, and thus, deeper flooding (7 inches) is required to control them. ("Early" and "late" refer to flowering times. Early watergrass flowers about 40 days after flooding, well ahead of rice. Late watergrass flowers about 90 days after flooding, which is at or near the same time as early rice varieties.) Both early and late watergrass are larger seeded than typical barnyardgrass and more successful in emerging through continuous floodwater.

Field draining encourages watergrass germination. Exposing the soil to air for long enough to allow secondary root development in watergrass seedlings (3–5 days) greatly reduces the effectiveness of currently used watergrass herbicides. Very severe infestations of watergrass may require rotation to another crop.

Sprangletop (Leptochloa spp.) usually does not germinate and emerge through a depth of more than 4 inches of water. If the field is drained, however, sprangletop seeds germinate rapidly and subsequent plant growth is virtually uncontrolled when reflooding occurs.

Broadleaf weeds and sedges.
Broadleaf weeds and sedges vary in their response to water depth and are much less susceptible to drowning than the grass weeds. In addition, some broadleaf weeds and sedges are favored by extremely shallow water depths or field draining. These weeds usually appear earlier than the grasses and are of a wider age-range in drained fields. The lack of uniform weed seed germination and development may reduce the effectiveness of broadleaf herbicides and timing of these herbicides for optimum weed control. However, short periods of drought can make rice more competitive against ricefield bulrush, so use these temporary periods of drought as a tool to help suppress ricefield bulrush.

MONITORING

Monitoring and accurate identification of weed species are necessary for choosing the best weed control program. Monitoring is especially important because herbicides used in rice are selective and control few weed species in the field. Also, where weed resistance exists, monitoring is crucial in making correct management decisions.

Keep good records of your monitoring to help select an herbicide, herbicide combination, or herbicide sequence. For assistance in weed identification, consult the color photos of weeds linked to COMMON AND SCIENTIFIC NAMES OF WEEDS section.

There are two major monitoring periods for weeds in rice: (1) from flooding until 45 days after seeding, and (2) between panicle initiation and heading.

- The first monitoring period determines weed control needs for the current season.
    - Monitor every 3 to 4 days after flooding for 21 days and once a week thereafter until the postemergence herbicide period is over (about 45 days after seeding).
    - Identify and record weed species and their distribution throughout each basin as well as the growth stage of the rice plant so that the proper herbicide(s) can be selected and applied at the appropriate time. The period of time from 21 to 45 days after seeding is especially critical for monitoring and treating weeds showing herbicide resistance before they go to seed.
- During the second monitoring period, record the weed species that have escaped control and their distribution in the field. This information is important for knowing what weeds to expect the following year. Also note species that appear to be resistant to herbicides; this will help to implement strategies that prevent further spread of resistant weeds. However, failure to achieve expected weed control levels does not usually mean there is resistance.

For more information on indicators of herbicide resistance as well as other reasons for herbicide failures, see the section on HERBICIDE RESISTANCE below.

HERBICIDES

With the onset of widespread weed resistance, many new herbicides have been registered. Most of the newly registered herbicides are limited in the spectrum of weeds controlled. While they may be applied alone for weed control, they are more frequently used in combinations or in sequence with another herbicide. To select the most effective herbicide(s) for a specific situation, several characteristics of the herbicide should be considered. These characteristics for herbicides currently registered for use in California rice fields are summarized in the table below:

Summary of Characteristics of Rice Herbicides

Common name (Example trade name)	Foliar activity [1]	Applied in water [2]	Translocation index [3]	Timing window [4]	Residual (days) [5]	Mode of action [6]	Weed resistance [7]
bensulfuron (Londax)	yes	yes *	4	0–5 lsr	35–40	2	yes

benzobicyclon/ halosulfuron (Butte)	yes	yes	4	0–4 lsr	30	27/2	see comment [8]
bispyribac (Regiment)	yes	no	4	5 lsr–mt	0	2	yes
carfentrazone (Shark)	yes	yes *	2	2–5 lsr	5–8	14	no
clomazone (Cerano)	no	yes	6	0–1 lsr	5 (water)	13	limited
cyhalofop-butyl (Clincher)	yes	no	4	2 lsr–mt	0	1	yes
halosulfuron (Sandea, Halomax)	yes	yes *	4	0–5 lsr	30	2	yes
orthosulfamuron (Strada)	yes	yes *	4	2–4 lsr	12–24	2	yes
pendimethalin (Prowl)	no	no	0	0 or 4–6 lsr	5 (water) 20 (dry soil)	3	no
penoxsulam (Granite)	yes	yes	4	2 lsr–mt	0	2	yes
propanil (Stam, SuperWham)	yes	no	3	3 lsr–mt	0	7	yes
propanil/ halosulfuron (RiceEdge)	yes	no	3	1–3 lsr	0–30	7/2	yes
thiobencarb (Abolish)	yes	yes *	3	2–3 lsr	20–25	8	yes
thiobencarb (Bolero)	no	yes	3	2 lsr	20–25	8	yes
thiobencarb/ imazosulfuron (League MVP)	no	yes	3	1–2 lsr	20–25	8/2	yes
triclopyr (Grandstand)	yes	no	8	5 lsr–mt	0	4	no

[1] *Foliar Activity.* Herbicides that must be directly sprayed on the plant to be effective are said to be foliar active and often require fields to be drained before they are applied so the weeds are adequately exposed to the spray.

[2] *Applied in Water.* Herbicides that are formulated as granules (e.g., Bolero Ultramax) are active through the soil and do not require field draining. Herbicides marked with an asterisk (*) are formulated as a spray for foliar contact but are also adsorbed to the soil when sprayed into the water so that plants take them up through the roots as well.

[3] *Translocation Index.* The translocation index provides a measure of how much the herbicide moves within the plant: numbers above 7 indicate highly mobile, numbers below 4 mean little movement. This index is important for water management when applying an herbicide. For example, if a foliar-applied herbicide is translocated in the plant, it may not be necessary to completely drain the field. If it is used in combination with a foliar herbicide that does not translocate (i.e., a contact herbicide), weed control would be compromised by not having the field drained fully to expose the weeds.

[4] *Timing Window.* Application timing is important to minimize rice injury and optimize weed control. Timing is stated in relation to the rice crop development: lsr=leaf stage of rice and mt = mid-tillering. Because several herbicides also work best when timed to the weed's stage of development, the timing window may be further reduced.

[5] *Residual Activity.* Residual activity is the length of time that the herbicide remains active in the soil and is generally determined by the amount and strength of soil adsorption and by the rate of degradation of the herbicide. Residual activity is important in herbicides that are applied early in the season because it helps to prevent reinfestation by subsequent germination of a new flush of weeds before the rice canopy is large enough to shade them out.

[6] *Mode of Action.* Weeds are resistant to the mode of action that kills them, not to the herbicide per se; consequently, once the weeds become resistant to a particular mode of action, all other herbicides with similar modes of action will likely fail to control the weed. To distinguish between herbicide modes of action, group numbers, assigned by the Weed Science Society of America (WSSA), are listed. Weeds with the same group number have the same mode of action. Although weeds may exhibit multiple resistance (resistance across many groups), mode-of-action numbers are useful in planning mixtures or sequences of herbicides. For more information, see http://wssa.net

[7] *Weed Resistance.* In fields where herbicide resistance has been identified, it is critically important to implement the herbicide resistance management strategies outlined below.

[8] No resistance has been confirmed for benzobicyclon, but there is resistance to halosulfuron.

Herbicide Resistance

Herbicide resistance is the ability of certain biotypes within a weed species to survive an herbicide treatment that would normally have killed it. Herbicide-resistant biotypes are present within a weed species' population as a part of normal genetic variation. Repeated use of the same herbicide or herbicides with the same mode of action will select for herbicide-resistant biotypes. In addition, the same weed can be resistant to more than one type of herbicide.

Factors that contribute to the development of herbicide resistance

In addition to the excessive reliance on chemical control and repeated sequential use of the same mode of action, herbicide resistance is promoted by

- a monoculture of continuous rice production,
- weeds that produce lots of seeds with little dormancy and short longevity,
- an herbicide that has high efficacy on a specific weed species, and
- an herbicide with prolonged residual activity.

Detecting herbicide resistance

Weed resistance may be occurring if monitoring indicates any of the following

- after treatment, healthy-looking plants are present alongside dead plants of the same species,
- one species that is normally controlled by the herbicide is poorly controlled, but other adjacent susceptible species are well controlled,
- a gradual decline in control has been noticed over time for a species that was previously well controlled by the same herbicide and rate,
- discrete patches of the target weed persistently survive treatment with a given herbicide or herbicides (escapes), and resistance in the same weed species and herbicide occurs in neighboring fields.

Resistance needs to be ultimately confirmed by a specific test. Failure to control weeds can be caused by several factors besides resistance; these include

- faulty spraying,
- incorrect dose or timing,
- unfavorable environmental conditions,
- weeds too large,
- subsequent weed germination after treatment,
- dense infestations, and
- poor coverage.

Also, keep in mind that weeds not on a label may tolerate the herbicide but are not resistant biotypes.

Types of Weed Resistance

In California, there are two types of weed resistance:

1) **Target site resistance** refers to resistance to group 2 —ALS inhibitors such as penoxsulam (Granite), sulfonylurea (Londax), and bispyribac (Regiment)— and group 7 —propanil (Stam or Super Wham)— mode-of-action herbicides. It can develop when mutations occur in one or more sites. The most common site mutation results in resistance to a sulfonylurea (Londax). If there is resistance to Londax, there is a greater probability for cross-resistance to other sulfonylureas and triazolopyrimidines, such as penoxsulam (Granite). If the mutation occurs at a different site, it may cause resistance to the pyrimidinylthiobenzoates, such as bispyribac (Regiment), but not to the

sulfonylureas or triazolopyrimidines. Finally, if the mutation occurs at a third site, resistance will be to all classes of ALS inhibitors.

Because the actual site where the mutation occurred will probably not be known, it is not possible to know when choosing an herbicide what cross-resistant patterns may be present for a resistant population. In these situations, choose an herbicide with a different mode of action or if there is no other choice available, use the ALS inhibitor in mixture or in sequence with a different mode-of-action herbicide that is active on the target weeds.

2) **Enhanced metabolic degradation resistance** is the second most common mechanism for resistance to rice herbicides; it affects primarily biotypes of barnyardgrass and the watergrasses. Herbicides with known enhanced metabolic degradation resistance include: mode-of-action group 1 —ACCase inhibitors: cyhalofop-butyl (Clincher)—; group 2 —ALS inhibitors: penoxsulam (Granite), sulfonylurea (Londax), and bispyribac (Regiment)—; group 8 —lipid inhibitors: thiobencarb (Abolish, Bolero)—; and group 13 —pigment inhibitor: clomazone (Cerano)—. **Note**: group 2 ALS inhibitors have exhibited both target site and enhanced metabolic resistances.

Barnyardgrass already has the ability to metabolize most rice herbicides, but very slowly, so the weed is killed before it can detoxify the herbicide. However with continuous use, particularly at low rates, you can select for biotypes that have enhanced ability to detoxify the herbicide. With tank mixes, however, the weed's ability to metabolize the herbicide can be influenced. For example, by mixing thiobencarb (Abolish) with bispyribac (Regiment), thiobencarb inhibits the metabolizing enzyme for bispyribac in early watergrass and prevents the weed from metabolizing bispyribac so that the weed is killed, but the phytotoxicity of bispyribac on rice is not increased.

Resistance Management

Use measures to prevent resistant weeds from going to seed, and manage weeds that have exhibited resistance so that their spread is prevented. Several cultural practices that suppress weed growth and reduce weed seed carryover are described below. Most importantly, use herbicides with different mode-of-action group numbers as alternates to, in combination with, or in sequential applications with the herbicide to which resistance has been developed.

Other management methods that help manage herbicide resistance include: the stale-seedbed technique; alternating stand establishment systems; monitoring field for weeds that have escaped treatment and controlling them along with late-season flushes; using certified seed; and maintaining a suppressive water depth. When in doubt, assume resistance and use appropriate resistant management strategies.

For more information on herbicide resistance by mode of action, see the California Rice Weed Herbicide Susceptibility Chart at UC Rice Online.

Cultural practices

Cultural practices that suppress weed growth and reduce weed seed carryover include:

1. Fallow and flood the field during the summer to germinate aquatic weeds (control these weeds mechanically or use nonselective herbicides).
2. Rotate to another crop to reduce the weed seed bank in the soil.
3. Suppress weed growth by using as many of the following methods as practical:
    - level fields to avoid unevenness,
    - use wind checks to prevent seedling drift,
    - cultivate and dry the seedbed to a 3-to-4 inch depth to destroy weed seedlings,
    - groove or crease the soil across the prevailing wind direction,
    - flood fields as rapidly as possible,
    - maintain a flood depth of 4 to 5 inches; deeper water (6 to 7 inches) suppresses certain weeds and may be useful in their control, and
    - avoid draining until the end of the season.

4. Where herbicide resistance has occurred, avoid moving resistant seed from one field to another in water or on tillage and harvesting equipment. To avoid this
- clean equipment before moving out of a field with known resistant weeds,
- till, plant, or harvest these fields last,
- hold water on the field to prevent the spread of resistant weed seeds, and
- use water management practices that best complement alternative herbicides used to control resistant weeds.

Herbicide use

Where possible, avoid using the herbicide to which weeds have become resistant in fields known to have resistant weeds. Use herbicides with different mode-of-action group numbers (along with the cultural practices described above) in combinations or sequences at the labeled rate and at the correct stages. Do not use group 1 —ACCase inhibitors: cyhalofop-butyl (Clincher)— or group 2 —ALS inhibitors: penoxsulam (Granite), sulfonylurea (Londax), bispyribac (Regiment), orthosulfamuron (Strada) and halosulfuron (Sandea) herbicides only or repeatedly in the same season.

To successfully manage herbicide resistance, an effective tank mix or sequential program (within a single season as well as over multiple cropping years) will include:
- herbicides with different mode-of-action group numbers, and
- herbicides with mode-of-action group numbers 4, 7, and 14 [i.e. 4 = triclopyr (Grandstand), 7 = propanil (Stam, SuperWham), and 14 = carfentrazone (Shark)], which do not have enhanced metabolic degradation resistance.

Herbicide Combinations.
Tank mixtures may be used when two or more herbicides are compatible, and the best management practices for their application such as timing and water depth are the same. Tank mix combinations reduce the cost of application and often reduce the rates of one or more herbicides. The purpose of combinations is to broaden the spectrum of weed control such that each herbicide in the mix will control weeds not controlled by the other. Use the SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL table to see the weed spectrum controlled by some of the common herbicides used in California rice.

Because almost all of the tank mixes in use in California have problems with resistant species of weeds, it is imperative to accurately identify weed species and the presence of herbicide resistance among the weeds. If resistance to barnyardgrass or the watergrasses is suspected in a field, avoid tank mixes of herbicides with mode-of-action group numbers 1, 2, 8, and 13 (1 = cyhalofop [Clincher]; 2 = penoxsulam [Granite], bensulfuron [Londax], bispyribac [Regiment], halosulfuron [Sandea]; 8= thiobencarb [Abolish, Bolero]; and 13 = clomaxone [Cerano]).

Herbicide Sequences
To achieve good broad-spectrum weed control, most herbicides must be used in sequence rather than in tank mixes because of differences in the herbicides with respect to timing, water management, antagonism, translocation and other factors. Another very important aspect of herbicide sequences is to protect against the buildup of weed resistance by using herbicides with different modes of action. For example, a sequence of cyhalofop, clomaxone, penoxulam, or bispyribac followed by propanil will generally control watergrass that is resistant to the first herbicide. Use the SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL table to see the weed spectrum controlled by some of the common herbicides used in California rice.

SPECIAL WEED PROBLEMS (6/19)

(Reviewed 6/19)

ALGAE Algae can smother rice seedlings or cause them to dislodge, resulting in yield loss. Algae are ubiquitous in the environment and grow well in the relatively shallow water conditions present in rice field. The species of algae present in a rice field shifts during the growing season from green algae and diatoms in early May to dominance by blue-green algae in late May-early June.

The amount of algae present in fields is associated with the concentration of phosphate in the water. In most cases, higher phosphorus levels result in a greater abundance of algae. Practices that reduce phosphorus inputs into the water, such as incorporating phosphorus fertilizer into the soil according to published UC recommendations, will lead to reduced algal growth. Copper compounds are available to control algae but must be applied before algal mats float to the surface. Some algae may be less susceptible to copper treatment than others, and the amount of residual rice straw present in a field from the previous growing season may reduce the efficacy of copper treatments.

AMERICAN PONDWEED (*Potamogeton nodosus),* **CATTAIL** (*Typha spp.),* **RIVER BULRUSH** (*Schoenoplectus fluviatilis),* **GREGG ARROWHEAD** (*Sagittaria longiloba*). Use deep plowing and crop rotation to reduce infestations of perennial weeds. Plow 8 to 12 inches deep to expose underground stems of cattails and Gregg arrowhead, tubers of river bulrush, and winter buds of American pondweed; this will usually reduce populations of these perennial weeds if sufficient drying of the soil and reproductive plant parts is attained in spring. Combining deep plowing (8 to 12 inches) with nonirrigated crop rotation, such as safflower, to facilitate soil desiccation is an even more effective management practice. Avoid transferring stems, tubers, and buds to clean fields by tillage equipment. Rotate to irrigated crops where effective herbicides and mechanical cultivation can be used to reduce perennial weed problems.

MARSHWEED (*Limnophila spp.*). *Limnophila indica* is a quarantined weed. All currently identified plants (15 from Butte County and 3 from Yuba County) in the Consortium of California Herbaria are identified as *Limnophila X ludoviciana* (a hybrid between *L. indica* and *L. sessiliflora*). The majority of samples have been taken from one general location in Butte County with the earliest collection being in 1977. Differences between these Limnophila are minute, making it difficult to positively identify them. It remains unclear whether there are any positive identifications of *L. indica* since there are currently no collections in the California herbaria. This plant is generally found in irrigation ditches and shallow water, like rice production fields. It is an emergent aquatic plant with small purple flowers. Technically, the hybrid is not *L. indica* and therefore not a quarantined weed.

SMALLFLOWER UMBRELLASEDGE (*Cyperus difformis***).** Populations of smallflower umbrellasedge have been identified to be resistant to propanil and ALS-inhibitors. If resistance is suspected in a field, first determine that the application equipment was operating properly, the rate of herbicide was appropriate, sufficient weed exposure was contacted by the application and the growth stage timing was appropriate. Once all these factors can be dismissed, collect a sample for official testing. Foliarly applied carfentrazone has been successful in controlling the propanil- and ALS-inhibitor-resistant smallflower populations. Many populations of this weed are already resistant to several herbicides, particularly the herbicides in group 2.

WATERGRASS (*Echinochloa spp.*). In California, watergrass, also known as barnyardgrass, is the most serious weed in continuously flooded rice. It is variable in form and three distinct species occur in California rice fields—terrestrial barnyardgrass, early watergrass, and late watergrass.

Terrestrial barnyardgrass is the most widespread and easiest to control by flood water. In fact, the California system of water-seeding rice was established to control this species and maintaining water 4 inches (10 cm) deep still provides good control. The larger-seeded watergrasses will grow through 4-inch deep water and thus deep flooding (7 to 8 inches) is required to control them. Watergrass tolerant to deep water can be selected for if not controlled by follow-up herbicide treatments. This is more typically a problem in organic production.

Watergrass seedlings can be controlled by preflood cultivation if they are dislodged before secondary roots begin to grow. Herbicides are also important in the control of watergrass but must be properly

timed to the growth stage of this weed in order to control it. Apply clomazone between day of seeding and one leaf stage of rice, penoxsulam at the two and a half leaf stage of rice, thiobencarb before the third leaf stage of watergrass, and propanil after the fourth leaf stage but before the stem elongates. Cyhalofop is applied when rice is between the 2-leaf stage to early tillering.

Very severe infestations of this weed may require rotation to another crop or alternative stand establishment techniques that reduce the population prior to seeding of rice.

WEEDY RICE (*Oryza sativa*). Weedy rice is a member of the same species as cultivated rice grown in California. It is also known as red rice, referring to the red bran covering the kernels. However, there are other weedy rice biotypes that have straw, gold, brown or black hull color. Weedy rice is a very troublesome weed for rice growers because it grows more vigorously than cultivated rice and competes better for resources, thus reducing rice yields. Seed heads of weedy rice mature over a long period of time and easily shatter when mature. Seed falls to the soil surface where it may germinate or remain dormant for several years. Certified seed is currently the best way to stop the spread of weedy rice.

Unfortunately, there are no selective herbicides to take weedy rice out of cultivated rice. Use hand rogueing (removing) of identifiable weedy rice plants prior to seed dispersal to control it. Additionally, do not disc the ground in the fall after rice is harvested to keep weedy rice seeds on the soil surface, allowing weather condition and predators to destroy them. Flooding the field in the fall without working out the ground may help cause seeds to rot.

Thoroughly clean harvesting equipment (combine, bank outs, trailers, etc.) in affected fields to make sure there is no carryover of weedy rice seed to other fields. In addition, make sure cleaning procedures include the removal of all plant material from the equipment, including mud from tires or tracks that may contain seeds.

This weed is currently found in 8 of the 9 major rice-growing counties in California. It has the potential to spread with increasing use of dry or drill-seeded rice. Eliminating this weed from infested fields is a multi-year effort because of the longevity of seed in the soil.

Domesticated colored bran varieties have been found in commercial white rice production and are often mistaken for weedy rice. Colored bran contaminants can reduce the grain grade of the intended rice crop.

To identify weedy rice and to learn more about weedy rice management, please visit the California Weedy Rice webpage.

WINGED PRIMROSE WILLOW (*Ludwigia decurrens*). Initial dicovery of *Ludwigia decurrens* in Butte county was in August 2011. The agricultural commissioners and UC cooperative extension advisors determined the infestation covered several square miles south of Richvale. Most infestations are along borders of fields and irrigation canals. One field had an infestation throughout. It is likely that this weed went undetected for several years.

Ludwigia decurrens can grow to six feet or higher and produce many four petalled yellow flowers and eventually will produce seed capsules. The stem of the plant is winged or star-shaped in cross-section.

Seed capsules from this plant have thousands of seeds which are capable of floating on the water surface as a means of dispersal, especially along irrigation canals; this could be the reason for weed dispersal across the majority of the infestation area. Seeds sticking to tillage equipment and seeds remaining in combines between harvested fields are other potential means of spread. Additionally, it has been determined that plant fragments have the ability to grow roots within a day or two when in water. This suggests not mowing levees as a means of control because this practice may actually increase dispersal of this weed.

Testing in the greenhouse at the Rice Experiment Station at Biggs, California indicates that the plant germinates best when the soil is moist but not flooded. However, the seed can germinate under water and eventually grow above the water surface with the potential to survive in a rice field and set seed. This plant also has the ability to form roots that grow upwards through the water column in order to scavenge oxygen near the water surface.

Containment and erradication efforts continue where it has been identified. These efforts will need to continue for many years to achieve complete erradication. A strong, competitive rice crop combined with some of the registered herbicides —e.g., triclopyr (Grandstand)— will help keep this weed in check within conventionally grown rice fields.

To identify winged primrose willow and learn more about its management, please visit the Winged Primrose Willow webpage at University of California's Agronomy Research and Information Center: Rice.

COMMON AND SCIENTIFIC NAMES OF WEEDS

(6/19)
(Reviewed 6/19)

Common Name	Scientific Name	Weed Type
arrowhead, California	*Sagittaria montevidensis*	annual broadleaf
arrowhead, Gregg	*Sagittaria longiloba*	perennial broadleaf
barnyardgrass	*Echinochloa crus-galli*	annual grass
bulrush, ricefield	*Schoenoplectus mucronatus*	annual sedge
bulrush, river	*Schoenoplectus fluviatilis*	perennial sedge
cattails	*Typha* spp.	perennial aquatic
ducksalad	*Heteranthera limosa*	annual broadleaf
marshweed	*Limnophilia* spp.	perennial aquatic
pickerelweed	*Monochoria vaginalis*	annual broadleaf
pondweed, American	*Potamogeton nodosus*	perennial aquatic
redstems	*Ammannia* spp.	annual broadleaf
sedge, smallflower umbrella	*Cyperus difformis*	annual sedge
sprangletop, bearded	*Leptochloa fusca ssp. fascicularis*	annual grass
sprangletop, Mexican	*Leptochloa fusca ssp. uninervia*	annual grass
water hyssop	*Bacopa spp.*	aquatic broadleaf
watergrass, early	*Echinochloa oryzoides*	annual grass
watergrass, late	*Echinochloa phyllopogon*	annual grass
waterplantain, common	*Alisma plantago-aquatica*	aquatic broadleaf
weedy rice	*Oryza sativa*	annual grass
winged primrose willow	*Ludwigia decurrens*	annual broadleaf

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (6/19)

(Reviewed 6/19,)

	BEN	BEZ/HAL	BIS	CAR	CLO	CYH	HAL	ORT	PEN	PEO	PNX	PRO*	PRO*/ HAL	THI*	THI/ IMA	TRI
Mode of Action	**2**	**27/2**	**2**	**14**	**13**	**1**	**2**	**2**	**3**	**2**	**2**	**7**	**7/2**	**8**	**8/2**	**4**
ANNUAL GRASSES																
barnyardgrass	N	C	C[1]	N	C[1]	C[1]	N	P[1]	C	C[1]	C[1]	C[1]	C[1]	C[1]	C[1]	N
sprangletop, bearded	N	C	N	N	C[1]	C[1]	N	N	P	N	N	N	N	C	C	N
watergrass, early	N	C	C[1]	N	C[1]	C[1]	N	P[1]	P[1]	C[1]	C[1]	C[1]	C[1]	C[1]	C[1]	N
watergrass, late	N	P	C[1]	N	C[1]	C[1]	N	P[1]	P[1]	C[1]	C[1]	C[1]	C[1]	C[1]	C[1]	N
ANNUAL BROADLEAVES/SEDGES																
arrowhead, California	C[1]	C	C[1]	C	N	N	C[1]	C[1]	N	C[1]	C	P	C[1]	N	C1	N
bulrush, ricefield	C[1]	C	P[1]	C	N	N	C[1]	C[1]	N	C[1]	P[1]	P[1]	C[1]	N	P[1]	C
ducksalad	C	C	C	P	N	N	C	—	N	C	C	P	C	N	C	N
redstems	C[1]	P	P[1]	C	N	N	C[1]	C[1]	N	C[1]	P[1]	P	C[1]	N	P[1]	C
sedge, smallflower umbrella	C[1]	C	P[1]	C	N	N	C[1]	C[1]	P	C[1]	C[1]	C[1]	C[1]	C[1]	C	N
PERENNIALS																
arrowhead, Gregg	N	C	N	N	N	N	C[1]	—	—	N	—	N	C[1]	N	N	N
monochoria (pickerelweed)	N	C	C	P	N	N	C	C	N	C	C	P	C	N	C	N

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

BEN	= bensulfuron (Londax)	PEN	= pendimethalin (Prowl H_2O)
BEZ/HAL	= bensulfuron/halosulfuron (Butte)	PEO	= penoxsulam (Granite SC)
BIS	= bispyribac-sodium (Regiment)	PNX	= penoxsulam (Granite GR)
CAR	= carfentrazone-ethyl (Shark H_2O)	PRO	= propanil* (Stam, Superwham)
CLO	= clomazone (Cerano)	PRO/HAL	=propanil/halsulfuron (RiceEdge)
CYH	= cyhalofop butyl (Clincher)	THI	= thiobencarb* (Abolish, Bolero Ultramax)
HAL	= halosulfuron (Sandea)	THI/IMA	= thiobencarb/imazosulfuron (League MVP)
ORT	= orthosulfumaron (Strada)	TRI	= triclopyr (Grandstand)

[1] Resistance known to occur. For more information on herbicide resistance by mode of action, see the California Rice Weed Herbicide Susceptibility Chart at UC Rice Online.

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

HERBICIDE TREATMENT TABLE (6/19)

(Reviewed 6/19)

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

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

SINGLE HERBICIDE APPLICATIONS (AFTER PLANTING)

A. BENSULFURON — 0.06 lb a.i.
(Londax) — 1.66 oz — 24 — 80
RESISTANCE: some populations of smallflower umbrella sedge, ricefield bulrush, California arrowhead, redstem
RESIDUAL: 35–40
MODE-OF-ACTION GROUP NUMBER[1]: 2 (sulfonylurea: ALS inhibitor)
APPLICATION TIMING: early: 1–3 lsr, later: 4 lsr to 1–2 til
MODE OF APPLICATION: early: into water, later: water receded to 70% exposed foliage
COMMENTS: Provides grass suppression while controlling numerous broadleaves, including ducksalad. Provides residual activity up to 40 days and can be tank-mixed with several other herbicides to increase weed control spectrum. Apply into static water to prevent movement of the herbicide and loss of weed control. Areas most likely to lose weed control following the application of this herbicide are in uppermost basins or around rice boxes where water has been allowed to flow. Water depth is less important than holding the water static. If water depth subsides before 5 days, water can be added but some loss of weed control may occur where water movement is greatest. If rice is poorly rooted because of wind or other damage, allow it ample time to anchor before using bensulfuron, otherwise rice root development may be delayed. May be applied as a spray solution or as a direct dry flowable product. Sprays are applied with conventional booms and the dry flowable formulation by precision low volume metering equipment, both by aircraft. Do not use on wild rice.

B. BISPYRIBAC-SODIUM — 0.03–0.04 lb a.i.
(Regiment CA) — 0.53–0.8 oz — 12 — 0
RESISTANCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, California Arrowhead
RESIDUAL: 0 days
MODE-OF-ACTION GROUP NUMBER[1]: 2 (pyrimidinyl-thiobenzoates: ALS inhibitor)
APPLICATION TIMING: early: 4 lsr, later: to 1st til
MODE OF APPLICATION: early: drained but wet field, later: water receded to 70% exposed foliage
COMMENTS: Controls wide-spectrum, including watergrass, ricefield bulrush, California arrowhead, ducksalad, and waterhyssop, but not smallflower umbrella sedge. High rate is needed for control of resistant late watergrass.

C. CARFENTRAZONE-ETHYL — 0.1–0.19 lb a.i.
(Shark H2O) — 4–7.6 oz (see comments) — 12 — 60
RESISTANCE: no
RESIDUAL: 5–8 days
MODE-OF-ACTION GROUP NUMBER[1]: 14 (triazolinone: inhibits PPO)
APPLICATION TIMING: 2–4 lsr or 20–45 days postseeding depending on floodwater coverage of weeds
MODE OF APPLICATION: into water (either when weeds are submerged or 80% of weed foliage exposed)

COMMENTS: Controls broadleaf weeds and sedges; can be used where bensulfuron (Londax), halosulfuron (Sandea), orthosulfamuron (Strada CA), or propanil resistance occurs. Can be tank-mixed with herbicides that control grasses. Hold the water at a static depth for at least 5 days after application. Once field is flooded, water must be held for at least 23 days after application before water is released. Only ground application allowed in pin-point flooded fields. Direct-dry application or direct-stream application recommended to prevent drift to other crops. Direct-dry application by fixed wing aircraft registered under two Special Local Needs labels (wild rice: EPA SLN No. CA-05007, other rice: EPA SLN No. CA-020007). Direct stream application by helicopter or ground registered under a Special Local Needs Label (EPA SLN No. CA-020008). Application rate for aerial-applied carfentrazone is 4–7.5 oz for wild rice and 7.5 oz for other rice.

D. CLOMAZONE — 0.4–0.6 lb a.i.
(Cerano 5 MEG) — 8–12 lb (see comments) — 12 — 120

RESISTANCE: some populations of barnyardgrass, watergrasses, sprangletop
RESIDUAL: 5 days in water
MODE OF ACTION GROUP NUMBER[1]: 13 (isoxazolidinone: carotenoid biosynthesis inhibitor)
APPLICATION TIMING: preseeding to l lsr
MODE OF APPLICATION: into water
COMMENTS: Different mode of action from other herbicides currently registered for use in rice; controls watergrass populations that are resistant to other herbicides and helps prevent the increase of such resistance. Reduced rate of 8 lb per acre may be used to control sprangletop and in certain soil types (see label for more information). May cause cosmetic injury to rice (bleaching, stunting, reduction in stand density), but no significant yield reductions have been observed.

E. COPPER SULFATE PENTAHYDRATE#
(Copper Sulfate Crystals)# — Freshwater algae: 6.8–13.6 lb; Other algae: 2.72–5.44 lb — 48 — 0

APPLICATION TIMING: see comments
MODE OF APPLICATION: into water
COMMENTS: Apply higher rate in deeper water (6-inch depth or greater). Best results are obtained when very fine granules or crystals are dropped into the floodwater; or when the copper sulfate is dissolved in water and sprayed. Apply treatments as the algae forms on the soil surface and organic matter and air pockets are beginning to form under the algae (causing it to start to rise to the surface of the water and float). Once the algae has floated to the surface and formed large mats, control is very difficult. Fields irrigated from wells often have algae problems and should be watched carefully. Hard water (excess carbonate) will tend to negate the effects of copper sulfate. Copper sulfate rates of 6.8 to 13.6 lb with 48-hour water-holding period for control of freshwater algae is allowed under a Special Local Needs label (EPA SLN No. CA-130013), which expires December 31, 2023.

F. CYHALOFOP — 0.24–0.27 lb a.i.
(Clincher CA) — 13–15 fl oz — 12 — 60

RESISTANCE: some populations of barnyardgrass, watergrasses and sprangle top
RESIDUAL: 0 days
MODE-OF-ACTION GROUP NUMBER[1]: 1 (aryloxyphenoxy-propionate: ACCase inhibitors)
APPLICATION TIMING: early: 1–2 lsr; later: 3 lsr to mid til
MODE OF APPLICATION: early: drained field, later: water receded to 70% exposed foliage
COMMENTS: Used for grass control in situations where thiobencarb (Abolish/Bolero) cannot be used because of delayed phytotoxicity syndrome. Effective on susceptible watergrass and sprangletop. Safe to rice crop. Ground application is required in some areas because of sensitivity of fruit trees. Use low rate on grasses that have up to four leaves, before tillering. Use high rate on tillered grasses.

G. HALOSULFURON — 0.031–0.062 lb a.i.
(Sandea) — 0.67–1.33 oz — 12 — 69

RESISTANCE: some populations of smallflower umbrella sedge, ricefield bulrush, California arrowhead, redstem
RESIDUAL: 35–40 days
MODE OF ACTION GROUP NUMBER[1]: 2 (sulfonylurea: ALS inhibitor)
APPLICATION TIMING: 1–2 (dry broadcast) or 3–5 lsr (foliar application)
MODE OF APPLICATION: into water, foliar spray (70 to 80% of weed foliage exposed), or dry broadcast
COMMENTS: Halosulfuron controls broadleaf and sedge weeds. It can cause rice stunting; however, plants usually recover from these symptoms.

H. ORTHOSULFAMURON — 0.053–0.065 lb a.i.

	(Strada CA)	1.7–2.1 oz	12	0

RESISTANCE: some populations of smallflower umbrella sedge, ricefield bulrush, California arrowhead, redstem
RESIDUAL: 25 days
MODE-OF-ACTION GROUP NUMBER[1]: 2 (sulfonylurea: ALS inhibitor)
APPLICATION TIMING: 2 to 4 lsr
MODE OF APPLICATION: foliar, early postemergence to preflood (dry-seeded rice), early postemergence or middle-to-late postemergence (at least 70% of weed foliage exposed)
COMMENTS: Orthosulfamuron controls broadleaf and sedge weeds. It is particularly effective on *Monochoria*. It can cause some rice stunting; however, plants usually recover from these symptoms.

I.	PENDIMETHALIN	0.71–0.95 lb a.i.		
	(Prowl H2O)	1.5–2 pt (see comments)	24	0

RESISTANCE: no
RESIDUAL: 20 days (dry soil); 5 days (water)
MODE-OF-ACTION GROUP NUMBER[1]: 3 (dinitroaniline: microtubule assembly inhibitor)
APPLICATION TIMING: 0 or 4–6 lsr
MODE OF APPLICATION: drained field (dry top layer of soil)
COMMENTS: Prowl H2O is generally used in direct-seeded rice. It can be used before or after the initial flush of water, but apply it prior to the emergence weeds. Its efficacy is during the germination period of seeds, and therefore it will not control established weeds. Rice is relatively tolerant to Prowl H2O once it has imbibed sufficient moisture for germination. Activity of Prowl H2O diminishes with additional water flushes and degrades quickly with flooding. See label for specific rates based on soil type. Not for use on grain-drilled, dry-seeded rice in California.

J.	PENOXSULAM	0.036–0.044 lb a.i. (Granite GR) 0.031–0.043 lb a.i. (Granite SC)		
	(Granite GR)	15–18.5 lb	12	60
	(Granite SC)	2–2.8 fl oz	12	60

RESISTANCE: some populations of barnyardgrass and watergrasses, ricefield bulrush, redstem, and California arrowhead
RESIDUAL: 35–40 days
MODE OF ACTION GROUP NUMBER[1]: 2 (triazolopyrimidine: ALS inhibitor)
APPLICATION TIMING: **Granite GR:** after 2.5 lsr; **Granite SC:** 4 lsr to 60 days before harvest
MODE OF APPLICATION: into water or foliar
COMMENTS: Granite GR (granular formulation) will control many weed species. It tends to stunt early root growth of rice. Granite SC (liquid suspension formulation) is generally applied on foliage at later stages of rice growth when floodwater is dropped for good exposure of weeds. Since Granite SC is usually applied later, it causes less phytotoxicity to the rice plant. Do not use on wild rice.

K.	PROPANIL*	3–6 lb a.i.		
	(Stam 80 EDF-CA, SuperWham! 80DF-CA)	3.75–7.5 lb	24	60

RESISTANCE: Some populations of barnyardgrass, early and late watergrass, bulrush and smallflower umbrellasedge
RESIDUAL: 0 days
MODE OF ACTION GROUP NUMBER[1]: 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Stam 80EDF =** early: from 3 lsr; **SuperWham! 80DF** = later: to mid-tiller
MODE OF APPLICATION: **Stam 80EDF** = early: drained field; **SuperWham! 80DF** = later: water receded to 70% exposed foliage
COMMENTS: A contact herbicide that controls an array of weeds such as watergrass, barnyardgrass, sedges, while suppressing sprangletop and other broadleaf weeds. Early treatments control watergrass more effectively; however, application generally must be delayed 35 to 50 days after seeding to control emerged broadleaf weeds. This allows adequate time for broadleaf weeds to develop sufficient foliage. If earlier watergrass control is desired under these conditions, a postplant treatment of thiobencarb is recommended. Can be applied by either ground or air in 10 to 15 gallons of water. Use higher volume to get better coverage and control of large grasses or dense weed populations. Use the low rate on young watergrass (30–35 days after seeding) in very shallow water to assure good coverage of the weed. Use the high rate when most watergrass is 6 to 9 inches above the water. Leaf injury (tip burn) may occur on rice when the temperature is above 85° to 90°F at the time of the application. **Do not use propanil within 14 days of an application of a carbamate (such as carbaryl) or organophosphate (such as malathion).** (Exception: Low dosages of insecticide as used for mosquito larva control in rice fields may be applied 5 days before or after application of propanil.)

L.	THIOBENCARB*	3–4 lb a.i. (Abolish)

		3.495 lb a.i. (Bolero Ultramax)		
	(Abolish 8EC)	3–4 pt	7 days	0
	(Bolero Ultramax)	23.3 lb	7 days	0

RESISTANCE: some populations of barnyardgrass, watergrasses and smallflower umbrella sedge
RESIDUAL: 25 days
MODE OF ACTION GROUP NUMBER[1]: 8 (thiocarbamate: inhibits lipid synthesis)
APPLICATION TIMING: **Abolish 8EC =** 2–3 lsr; **Bolero Ultramax** = 2 lsr
MODE OF APPLICATION: **Abolish 8EC** = drained field; **Bolero Ultramax** = applied in water
COMMENTS: Mostly used for grass control but also provides some control of smallflower umbrella sedge and selected broadleaf weeds. Abolish may be applied preflood to fields that are immediately flooded, however, the effective residual period after flooding is considerably short. Both Abolish 8EC and Bolero Ultramax may be applied after the crop has emerged, but the window for rice safety and weed control is very narrow. Because timing of thiobencarb to weeds and rice is so important, the following situations should be avoided: fields that take longer than 5 days to flood and fields with greater than 0.2 foot fall to avoid deep-water stress. Use caution when using dry coated seed because it delays germination, which narrows the application window by allowing watergrass to become too large while rice is still in the sensitive stage. Make postplant application when 70% of the rice seedlings have reached the 2-leaf stage. Rice is very sensitive to these formulations at the one-leaf stage and may be severely injured if it is applied too early. Thiobencarb provides residual activity of about 25 days. It will not be effective on watergrass or barnyardgrass beyond the 3-leaf stage. **Do not use within 14 days of an application of a carbamate (such as carbaryl) or organophosphate (such as malathion). Note:** Check with agricultural commissioner for water-holding requirements following all thiobencarb applications. Do not make more than one application per year.

M.	TRICLOPYR	0.25–0.375 lb a.e.		
	(Grandstand CA)	0.67–1 pt	48	60

RESISTANCE: no
RESIDUAL: 0 days
MODE OF ACTION GROUP NUMBER[1]: 4 (pyridine carboxylic acid: auxin-type herbicide)
APPLICATION TIMING: early: from 1st til, later: to max. til
MODE OF APPLICATION: early: drained field, later: water receded to 70% exposed foliage
COMMENTS: Used for ricefield bulrush, redstem, and waterhyssop; is not effective for grass control. Apply by air or ground; weeds should be actively growing at time of treatment and well above the water surface. A translocated herbicide that requires that only 70% of the weed foliage be exposed for adequate spray coverage. Consult your county agricultural commissioner for current water management restrictions. If the water level is dropped to expose weeds before treatment, do not raise the water level for at least 48 hours after application. Do not make more than two applications per season and allow at least 20 days between applications. May be tank mixed with propanil. Do not allow drift to sensitive crops. See label for other restrictions.

HERBICIDE TANK MIXES AND PREMIXES

Note: If resistance to barnyardgrass or watergrasses is suspected in a field, avoid combinations or sequences of herbicides with mode-of-action group numbers 1, 2, 8, and 13 (1 = cyhalofop [Clincher CA]; 2 = penoxsulam [Granite], bensulfuron [Londax], bispyribac [Regiment CA], halosulfuron [Sandea]; 8= thiobencarb [Abolish 8EC, Bolero]; and 13 = clomazone [Cerano 5 MEG]). *For all tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label.*

A.	BENZOBICYCLONE/HALOSULFURON	0.23–0.27 lb a.i. (benzobycyclon) 0.019–0.058 lb a.i. (halosulfuron methyl)		
	(Butte)	7.5–9 lb	12	82

RESISTANCE: No resistant weeds for benzobicyclon for were reported in California.
RESIDUAL: Benzobicyclon = 14 days, halosulfuron = 30 days
MODE-OF-ACTION GROUP NUMBERS[1]: 27 (Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase, HPPD) plus 2 (sulfonylurea: ALS inhibitor)
MODE OF APPLICATION: Benzobicyclon, the major component of the formulation, is a pro-herbicide and the formulated product must be applied into flooded fields to allow for conversion to the herbicidal active ingredient. Application to dry soils will provide minimal weed control. Average water depth at application should be a minimum of 4 inches with no bare soil.

APPLICATION TIMING: Apply at day of seeding to 4 true leaf rice, however, weed control efficacy can be significantly reduced at 4 true leaf rice stage
COMMENTS: Butte can only be used in rice that will be followed by rice the following year. Do not make more than one application or apply more than 9 lb of Butte (0.27 lb ai Benzobicyclon) and (0.058 lb Halosulfuron-methyl) per annual growing season. Minimum water hold period for Butte is twenty (20) days.

B.	BISPYRIBAC-SODIUM	0.0265–0.0335 lb a.i		
	(Regiment CA)	0.53–0.67 oz	12	0
	...PLUS...			
	CARFENTRAZONE-ETHYL	0.19 lb a.i.		
	(Shark H2O)	7.6 oz	12	60

RESISTANCE FOR TANK MIX: some populations of barnyardgrass and watergrasses
RESIDUAL: **Regiment CA** = 0 days; **Shark H2O** = 5–8 days
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (pyrimidinyl-thiobenzoates: ALS inhibitor) plus 14 (triazolinone: inhibits PPO)
APPLICATION TIMING: **Regiment CA** = 4–5 lsr; **Shark H2O** = 4-5 lsr
MODE OF APPLICATION: **Regiment CA** = 70% of weed foliage exposed; **Shark H2O** = flooded field or water lowered to reveal 80% of weed foliage.

C.	BISPYRIBAC-SODIUM	0.0265–0.0335 lb a.i.		
	(Regiment CA)	0.53–0.67 oz	12	0
	...PLUS...			
	THIOBENCARB*	2–3 lb a.i.		
	(Abolish 8EC)	2–3 pt	7 days	0

RESISTANCE FOR TANK MIX: some populations of barnyardgrass, watergrasses, ricefield bulrush, California arrowhead
RESIDUAL: **Regiment CA**= 0 days; **Abolish 8EC** = 20–25 days
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (pyrimidinyl-thiobenzoates: ALS inhibitor) plus 8 (thiocarbamate: inhibit lipid synthesis)
APPLICATION TIMING: **Regiment CA** = 5–6 lsr; **Abolish 8EC** = 5–6 lsr
MODE OF APPLICATION: **Regiment CA** = drained (but wet) field; **Abolish 8EC** = water level lowered to reveal 70% of weed foliage

D.	PROPANIL*	4–6 lb a.i.		
	(Stam 80 EDF-CA, SuperWham! 80DF-CA)	5–7.5 lb	24	60
	...PLUS...			
	PENOXSULAM	0.036 lb a.i.		
	(Granite SC)	2.3 fl oz	12	60

RESISTANCE FOR TANK MIX: Some populations of barnyardgrass, watergrass, sprangletop, smallflower umbrella sedge, ricefield bulrush
RESIDUAL: **Stam 80EDF, SuperWham!** = 0 days; **Granite SC** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 7 (amide: photosystem II inhibitor) plus 2 (triazolopyrimidine: ALS inhibitor)
APPLICATION TIMING: **Stam 80EDF, SuperWham! 80DF-CA** = 4–6 lsr; **Granite SC** = 4–6 lsr
MODE OF APPLICATION: **Stam 80EDF** = drained field, **SuperWham! 80DF-CA** = drained field; **Granite SC** = partially drained field (at least 70% of weed foliage exposed)

E.	PROPANIL*	3 lb a.i.		
	(Stam 80 EDF-CA, SuperWham! 80DF-CA)	3.75 lb	24	60
	...PLUS...			
	THIOBENCARB	3 lb a.i.		
	(Abolish 8EC)	3 pt	7 days	0

RESISTANCE FOR TANK MIX: Some populations of barnyardgrass, watergrass, sprangletop, smallflower umbrella sedge, ricefield bulrush
RESIDUAL: **Stam 80EDF-CA, SuperWham! 80DF-CA**= 0 days; **Abolish 8EC**= 20-25 days
MODE-OF-ACTION GROUP NUMBERS[1]: 7 (amide: photosystem II inhibitor) plus 8 (thiocarbamate: inhibit lipid synthesis)
APPLICATION TIMING: **Stam 80EDF-CA, SuperWham! 80DF-CA**= 2–3 lsr; **Abolish 8EC** = 2–3 lsr
MODE OF APPLICATION: **Stam 80EDF** = drained field, **SuperWham! 80DF-CA**= drained field; **Abolish 8 EC** = drained field
COMMENTS: For Abolish, application rate and mode of application varies based on field type, application timing, and soil type.

F.	PROPANIL*/HALOSULFURON	3–6 lb a.i. (propanil)

		0.023–0.046 lb a.i. (halosulfuron methyl)		
	(RiceEdge 60DF)	5–10 lb	24	69

RESISTANCE: Some populations of barnyardgrass, watergrass, sprangletop, smallflower umbrella sedge, ricefield bulrush
RESIDUAL: Propanil = 0, halosulfuron = 30
MODE-OF-ACTION GROUP NUMBERS[1]: 7 (amide: photosystem II inhibitor) plus 2 (sulfonylurea: ALS inhibitor)
MODE OF APPLICATION: drain field before application and bring water back 48 hours after application.
APPLICATION TIMING: 1 to 3 lsr

G.	THIOBENCARB/IMAZOSULFURON	3–3.5 lb a.i. (thiobencarb) 0.013–0.015 lb a.i. (imazosulfuron)		
	(League MVP)	30–35lb	12	0

RESISTANCE: some populations of barnyardgrass, watergrasses and smallflower umbrella sedge
RESIDUAL: thiobencarb = 20–25, imazosulfuron = 25
MODE-OF-ACTION GROUP NUMBERS[1]: 8 (thiocarbamate: inhibit lipid synthesis) plus 2 (pyrimidinyl-thiobenzoates: ALS inhibitor)
MODE OF APPLICATION: after flooding
APPLICATION TIMING: 2 lsr
COMMENTS: 12-hour REI allowed under a California supplemental label, which expires August 31, 2021.

HERBICIDE SEQUENCES WITH BISPYRIBAC-SODIUM (REGIMENT)

A.	BISPYRIBAC-SODIUM	0.0335–0.04 lb a.i		
	(Regiment CA)	0.67–0.8 oz	12	0
	...FOLLOWED BY...			
	PROPANIL*	6 lb a.i.		
	(Stam 80 EDF-CA, SuperWHAM 80 DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, smallflower umbrella sedge, only suppression of California arrowhead in a resistant population
RESIDUAL: **Regiment CA** = 0 days; **Stam 80 EDF, SuperWham! 80DF-CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (pyrimidinyl-thiobenzoates: ALS inhibitor) plus 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Regiment CA** = 4 lsr–1 til; **Stam 80EDF, SuperWham! 80DF-CA** = 2–3 til
MODE OF APPLICATION: **Regiment CA** = preflood to wet soil (dry-seeded), drained field (pinpoint flood), or 70% of weed foliage exposed (postflood); **Stam 80EDF** = drained field, **SuperWham! 80DF-CA** = 70% foliage exposed
COMMENTS: Resistance not yet a problem with propanil.

HERBICIDE SEQUENCES WITH CLOMAZONE (CERANO 5 MEG)

A.	CLOMAZONE	0.4–0.6 lb a.i.		
	(Cerano 5 MEG)	8–12 lb	12	120

COMMENTS: Used for grass control in situations where thiobencarb (Abolish/Bolero) cannot be used because of delayed phytotoxicity syndrome. Effective on susceptible watergrass and sprangletop. Safe to rice crop. Ground application is required in some areas because of sensitivity of fruit trees.

	...FOLLOWED BY...			
	BENSULFURON	0.06 lb		
	(Londax)	1.67 oz	24	80

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrass, poor control in Londax-resistant populations of smallflower umbrella sedge, ricefield bulrush, California arrowhead, redstem
RESIDUAL: **Cerano 5 MEG**= 5 days in water; **Londax** = 35–40 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: carotenoid biosynthesis inhibitor) followed by 2 (sulfonylurea: ALS inhibitor)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Londax** = 1–3 lsr
MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Londax** = into water

COMMENTS: Apply into static water to prevent movement of the herbicide and loss of weed control. Areas most likely to lose weed control following the application of this herbicide are in uppermost basins or around rice boxes where water has been allowed to flow. Water depth is less important than holding the water static. If water depth subsides before 5 days, water can be added but some loss of weed control may occur where water movement is greatest. If rice is poorly rooted because of wind or other damage, allow it ample time to anchor before using, otherwise rice root development may be delayed. Do not use on wild rice.

...or...

BISPYRIBAC-SODIUM	0.0335–0.04 lb a.i		
(Regiment CA)	0.67–0.8 oz	12	0

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrass, sprangle top, poor control in Regiment-resistant populations of ricefield bulrush and California arrowhead
RESIDUAL: **Cerano 5 MEG** = 5 days in water; **Regiment CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: carotenoid biosynthesis inhibitor) followed by 2 (pyrimidinyl-thiobenzoates: ALS inhibitor)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Regiment CA** = 2–3 til
MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Regiment CA** = 70% foliage exposed
COMMENTS: High rate of bispyribac-sodium could cause phytotoxicity to rice after an application of clomazone.

...OR...

CARFENTRAZONE-ETHYL	0.19 lb a.i.		
(Shark H2O)	7.6 oz (see comments)	12	60

RESISTANCE FOR SEQUENCE: some populations of watergrass, barnyardgrass, sprangle top
RESIDUAL: **Cerano 5 MEG** = 5 days in water; **Shark H2O** = 5–8 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: carotenoid biosynthesis inhibitor) followed by 14 (triazolinone: inhibits PPO)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Shark H2O** = 2–3 lsr
MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Shark H2O** = into water (when weeds are submerged or when 80% of weed foliage is exposed)
COMMENTS: Controls broadleaf weeds; can be used where bensulfuron (Londax) resistance occurs. Can be tank mixed with herbicides that control grasses. Hold the water at a static depth for at least 5 days after application. Once field is flooded, water must be held for at least 23 days after application before water is released. Only ground application allowed in pin-point flooded fields. Direct-dry application or direct-stream application recommended preventing drift to other crops. Direct-dry application and direct stream application by aircraft is registered under supplemental labels (for DDA by fixed wing aircraft in wild rice, EPA SLN No. CA-050007; for DDA in other rice, EPA SLN No. CA-020007; for DSA in other rice, EPA SLN No. CA-020008). Application rate for aerial-applied carfentrazone is 4–7.5 oz for wild rice and 7.5 oz for other rice.

...or...

PROPANIL	6 lb a.i.		
(Stam 80 EDF-CA, SuperWham! 80DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrass, sprangle top, ricefield bulrush, smallflower umbrella sedge
RESIDUAL: **Cerano 5 MEG** = 5 days in water; **Stam 80 EDF, SuperWham! 80DF-CA =** 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: carotenoid biosynthesis) followed by 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Stam 80 EDF, SuperWham! 80DF-CA** = 1 til to full til
MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Stam 80 EDF=** drained field**, SuperWham! 80DF-CA** = 70% foliage exposed

...OR...

PROPANIL* (in tank mix with TRICLOPYR)	4 lb a.i.		
(Stam 80 EDF-CA, SuperWham! 80DF-CA)	5 lb	24	60
...PLUS...			
TRICLOPYR	0.25 lb a.e.		
(Grandstand CA)	0.67 pt	48	60

RESISTANCE FOR SEQUENCE AND TANK MIX: some populations of barnyardgrass, watergrass, sprangle top
RESIDUAL: **Cerano 5 MEG** = 5 days in water; **Stam 80 EDF, SuperWham! 80DF-CA**= 0 days; Grandstand = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: carotenoid biosynthesis inhibitor) followed by 7 (amide: photosystem II inhibitor) plus 4 (pyridine carboxylic acid)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Stam 80 EDF, SuperWham! 80DF-CA**= 1til to full til
Grandstand CA = 2–3 lsr (preflood), 3–4 lsr (water-seeded)

MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Stam 80EDF** = drained field, **SuperWham! 80DF-CA**= 70% foliage exposed, **Grandstand CA** = preflood, or postflood when emerged weeds are above the floodwater
COMMENTS: No resistance to propanil.

HERBICIDE SEQUENCES WITH CYHALOFOP (CLINCHER)

A.	CYHALOFOP	0.24–0.28 lb a.i.		
	(Clincher CA)	13–15 fl oz	12	60

COMMENTS: Different mode of action from other herbicides currently registered for use in rice; controls watergrass populations resistant to other herbicides and helps prevent the increase of these resistant populations. May cause temporary injury to rice (stunting and reduction in stand density), but no significant yield reductions have been observed.
...FOLLOWED BY...

BENSULFURON	0.06 lb a.i.		
(Londax)	1.67 oz	24	80

RESISTANCE FOR SEQUENCE: poor control in Clincher-resistant populations of barnyardgrass and watergrasses; or poor control in Londax-resistant populations of smallflower umbrella sedge, ricefield bulrush, California arrowhead, redstem
RESIDUAL: **Clincher CA** = 0 days; **Londax** = 35–40
MODE-OF-ACTION GROUP NUMBERS[1]: 1 (aryloxyphenoxy-propionate: ACCase inhibitors) followed by 2 (sulfonylurea: ALS inhibitor)
APPLICATION TIMING: **Clincher CA**= 3–6 lsr; **Londax** = 2–3 til
MODE OF APPLICATION: **Clincher CA**= at least 70% of weed foliage exposed; **Londax** = 70% foliage exposed
COMMENTS: Apply into static water to prevent movement of the herbicide and loss of weed control. Areas most likely to lose weed control following the application of this herbicide are in uppermost basins or around rice boxes where water has been allowed to flow. Water depth is less important than holding the water static. If water depth subsides before 5 days, water can be added but some loss of weed control may occur where water movement is greatest. If rice is poorly rooted because of wind or other damage, allow it ample time to anchor before using, otherwise rice root development may be delayed. Do not use on wild rice.
...OR...

BISPYRIBAC-SODIUM	0.0335 lb a.i		
(Regiment CA)	0.67 oz	12	0

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top, ricefield bulrush, California arrowhead
RESIDUAL: **Clincher CA**= 0 days; **Regiment CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 1 (aryloxyphenoxy-propionate: ACCase inhibitor) followed by 2 (pyrimidinyl-thiobenzoates: ALS inhibitor)
APPLICATION TIMING: **Clincher CA**= 3–6 lsr; **Regiment CA** = 2–3 til
MODE OF APPLICATION: **Clincher CA**= 70% of weed foliage exposed, **Regiment CA** = 70% foliage exposed
COMMENTS: This sequence will control sprangletop but also can promote watergrass resistance; watch for uncontrolled weeds and be sure to control them.
...OR...

PROPANIL*	6 lb a.i.		
(Stam 80 EDF-CA, SuperWHAM 8 DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top, ricefield bulrush, smallflower umbrella sedge
RESIDUAL: **Clincher CA** = 0 days; **Stam 80 EDF, SuperWham! 80DF-CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 1 (aryloxyphenoxy-propionate: ACCase inhibitors) followed by 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Clincher CA**= 3-6 lsr; **Stam 80 EDF, SuperWham! 80DF-CA** = 2 til to full til
MODE OF APPLICATION: **Clincher CA**= at least 70% of weed foliage exposed, **Stam 80EDF** = drained field, **SuperWham!** = 70% foliage exposed
COMMENTS: No resistance to propanil.

B.	CARFENTRAZONE-ETHYL	0.19 lb a.i.		
	(Shark H2O)	7.6 oz (see comments)	12	60

COMMENTS: Controls broadleaf weeds; can be used where bensulfuron (Londax) resistance occurs. Can be tank mixed with herbicides that control grasses. Hold the water at a static depth for at least 5 days after application. Once field is flooded, water must be held for at least 23 days after application before water is released. Only ground application allowed in pin-point flooded fields. Direct-dry application or direct-stream application recommended to prevent drift to other crops. Direct-dry application and direct stream application by aircraft is registered under supplemental labels (for DDA by fixed wing aircraft in wild rice, EPA SLN No. CA-050007; for DDA in other rice, EPA SLN No. CA-020007; for DSA in other rice, EPA SLN No. CA-020008). Application rate for aerial-applied carfentrazone is 4 to 7.5 oz for wild rice and 7.5 oz for other rice.

...FOLLOWED BY...			
CYHALOFOP	0.27 lb a.i.		
(Clincher CA)	15 fl oz	12	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top
RESIDUAL: **Shark H2O** = 5–8 days; **Clincher CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 14 (triazolinone: inhibits PPO) followed by 1 (aryloxyphenoxy-propionate: ACCase inhibitors)
APPLICATION TIMING: **Shark H2O** = 2–4 lsr; **Clincher CA** = 1–3 til
MODE OF APPLICATION: **Shark H2O** = into water (either when weeds submerged or when 80% of weed foliage exposed); **Clincher CA** = water receded to 70% exposed weed foliage
COMMENTS: Different mode of action from other herbicides currently registered for use in rice; controls watergrass populations resistant to other herbicides and helps prevent the increase of these resistant populations. May cause cosmetic injury to rice (stunting and reduction in stand density), but no significant yield reductions have been observed.

C.

CYHALOFOP	0.27 lb a.i.		
(Clincher CA)	15 fl oz	12	60
...FOLLOWED BY...			
PROPANIL	6 lb a.i.		
(Stam 80 EDF-CA, SuperWham! 80DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top, ricefield bulrush, smallflower umbrella sedge
RESIDUAL: **Clincher CA** = 0 days; **Stam 80 EDF**, **SuperWham! 80DF-CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 7 (amide: photosystem II inhibitor) followed by 1 (aryloxyphenoxy-propionate: ACCase inhibitors)
APPLICATION TIMING: **Clincher CA** = 1–3 til; **Stam 80 EDF**, **SuperWham! 80DF-CA** = 5–6 til
MODE OF APPLICATION: **Stam 80EDF** = drained field, **SuperWham! 80DF-CA** = not completely drained field; **Clincher CA** = 70% foliage exposed
COMMENTS: Different mode of action from other herbicides currently registered for use in rice; controls watergrass populations resistant to other herbicides and helps prevent the increase of these resistant populations. May cause cosmetic injury to rice (stunting and reduction in stand density), but no significant yield reductions have been observed.

HERBICIDE SEQUENCES WITH PENOXSULAM (GRANITE)

A.

PENOXSULAM	0.036 lb a.i.		
(Granite GR)	15 lb	12	60
(Granite SC)	2.3 fl oz	12	60
...FOLLOWED BY...			
PROPANIL	6 lb a.i.		
(Stam 80 EDF-CA, SuperWham! 80DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: poor control with resistant populations of California arrowhead and redstem
RESIDUAL: **Granite GR** = NA; **Stam 80 EDF**, **SuperWham! 80DF-**CA = NA
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (triazolopyrimidine: ALS inhibitor) followed by 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Granite** = 3–4 lsr; **Stam 80 EDF, SuperWham! 80DF-CA** = 1–3 til
MODE OF APPLICATION: **Granite GR** = into water; **Granite SC** = partially drained field (at least 70% of weed foliage exposed); **Stam 80 EDF**= drained field**, SuperWham! 80DF-CA** = water receded to 70% exposed foliage
COMMENTS: If watergrass population is already widely resistant to Granite, this sequence will not protect propanil. Will not control sprangletop unless penoxsulam is mixed with cyhalofop (Clincher CA).

HERBICIDE SEQUENCES WITH THIOBENCARB (BOLERO)

A.	THIOBENCARB*	3.49 lb a.i.		
	(Bolero Ultramax)	23.3 lb	168 (7 days)	0
	...FOLLOWED BY...			
	BISPYRIBAC-SODIUM	0.0335 lb a.i.		
	(Regiment CA)	0.67 oz	12	0

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, California Arrowhead, only suppression of redstem in a resistant population.
RESIDUAL: **Bolero Ultramax** = 20-25 days; **Regiment CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 8 (thiocarbamate: inhibit lipid synthesis) followed by 2 (pyrimidinyl-thiobenzoates: ALS inhibitor)
APPLICATION TIMING: **Bolero Ultramax** = 2 lsr; **Regiment CA** = 4 lsr–til
MODE OF APPLICATION: **Bolero Ultramax** = into water; **Regiment CA** = water receded to 70% exposed foliage

...OR...

PROPANIL*	6 lb a.i.		
(Stam 80EDF CA, SuperWham! 80DF-CA)	7.5 lb	24	60

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, California arrowhead
RESIDUAL: **Bolero Ultramax** = 20-25 days; **Stam** 80EDF, **SuperWham!** 80DF-CA = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 8 (thiocarbamate: inhibit lipid synthesis) followed by 7 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Bolero Ultramax** = 2 lsr; **Stam** 80EDF, **SuperWham!** 80DF-CA = 1–3 til
MODE OF APPLICATION: **Bolero Ultramax** = into water; **Stam 80EDF =** drained field**, SuperWham! 80DF-CA** = water receded to 70% exposed foliage
COMMENTS: If the populations of barnyardgrass and watergrasses are already widely resistant to Bolero, this sequence will not protect propanil from resistance development. Broad-spectrum and useful for sprangletop.

‡ 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 (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

[1] Group numbers are assigned by the 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://wssa.net/wssa/weed/herbicides/.

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

lsr Leaf stage of rice

til Tillering stage

NA Not applicable

Precautions for Using Pesticides

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

Legal Responsibility

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

Transportation

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

Storage

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

Container Disposal

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

Protection of Nonpest Animals and Plants

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

Posting Treated Fields

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

Preharvest Intervals

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

Permit Requirements

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

Maximum residue levels

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

Processed Crops

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

Crop Injury

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

Personal Safety

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