UC IPM
Pest Management Guidelines: RICE

July 2024

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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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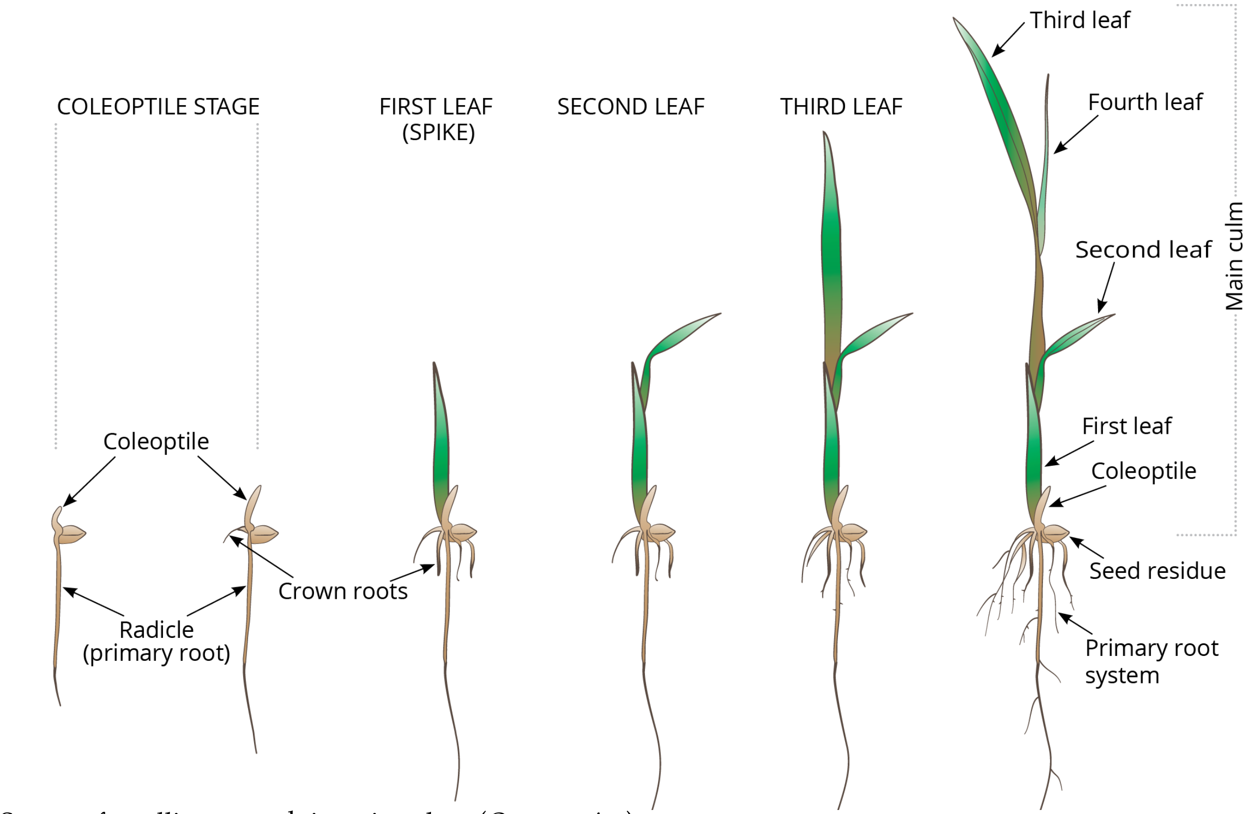
To be used with *Integrated Pest Management for Rice,* 3rd Edition UC ANR Publication 3280.

General Information

Rice Developmental Stages (07/24)

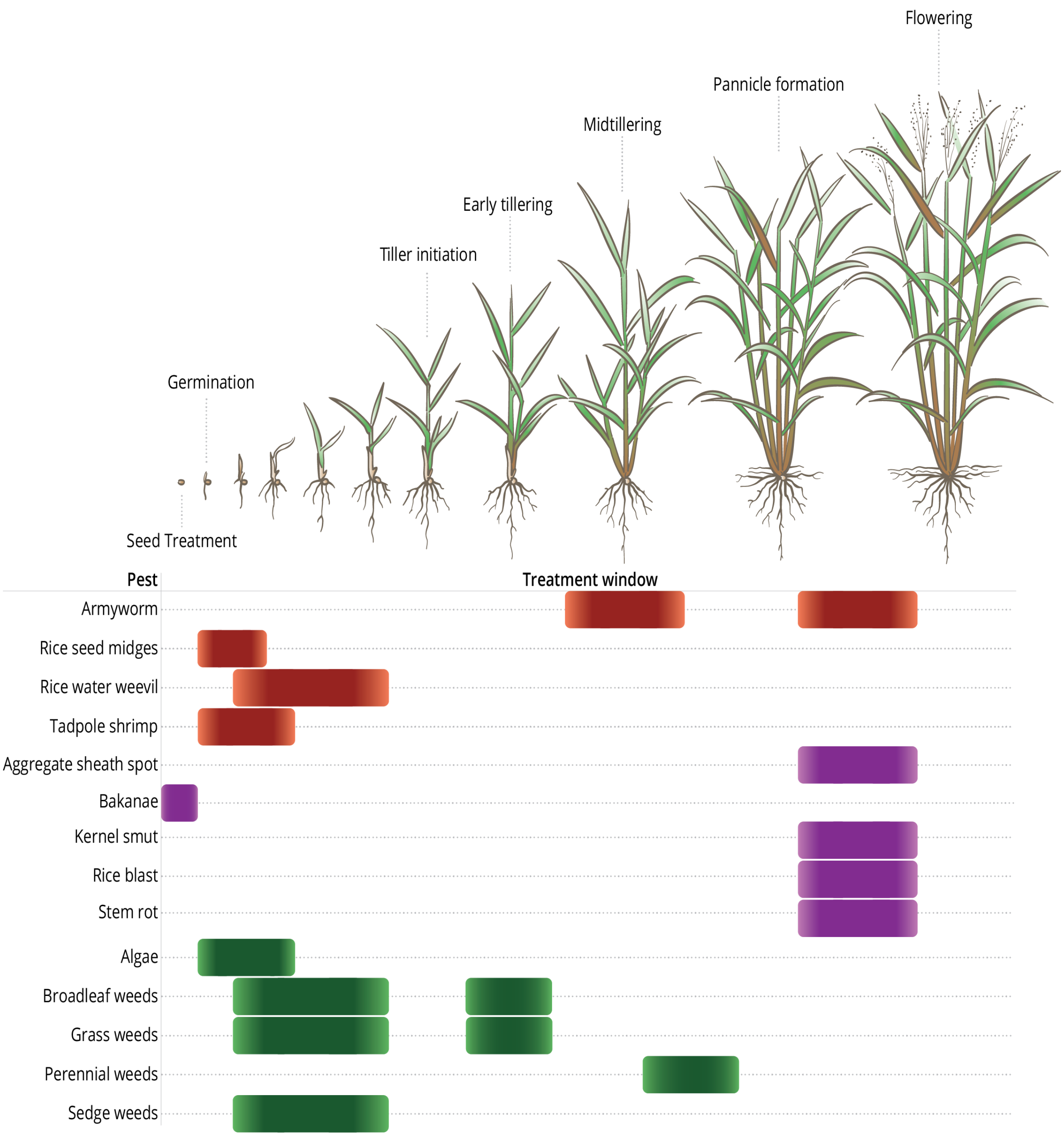
Development of Rice Seedling



Stages of seedling growth in a rice plant (*Oryza sativa*).

Treatment Periods for Most Effective Control in an IPM Program (07/24)

Treatment Windows for Pests based on Rice Growth Stage



Treatment windows for pests in rice (*Oryza sativa*).

Managing Mosquitoes in an Agricultural Setting (04/24)

Rice culture can provide a suitable environment for mosquitos to breed. In cases where rice fields 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 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 employ a variety of methods to manage mosquitoes in rice fields including insecticide applications and stocking fields with mosquitofish, *Gambusia affinis* that eat mosquito larva. Some mosquito control agencies use methoprene alone or in combination with the bacteria *Bacillus thuringiensis* spp. *israelensis* (Bti) or *Lysinibacillus* (*=Bacillus) sphaericus* (Ls), 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 using pyrethroids or malathion). These fogs do not kill fish or insects and aren't lethal for some of the invertebrates in the water. The fogs may, however, kill some terrestrial insects, especially smaller ones. To find out the specific control measures being used in your district, contact your local agency. This is especially important with certified organic fields.

Coordinate with mosquito abatement personnel so they can access roads to monitor fields. In addition to the control measures taken by mosquito abatement districts, there are numerous cultural practices growers can employ to help with mosquito control.

- Drain and eliminate borrow pits and seepage areas outside the field.
- Seek assistance from 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 unwanted effects of pesticides used in a pest management program on mosquitofish. Notify them if disruptive pesticides are used after the end of May so that they can monitor the fish populations.

Preserving Mosquito Predators

Many naturally-occurring insects in rice fields are predators of mosquitoes. These include backswimmers, scavenger beetle larvae, giant water bugs, predaceous diving beetles and their larvae, damselfly nymphs, and dragonfly nymphs. While these predators consume the majority of mosquito larvae, supplemental mosquito control is usually necessary because the mosquito larvae that survive can still mature into problematic numbers of adults. It is very important, however, to conserve the natural predators that accomplish most of the mosquito control. Whenever possible, follow integrated pest management practices for invertebrate pests that limit the use of broad-spectrum pesticides that are toxic to fish. This helps the survival of mosquitofish and other natural enemies of mosquitoes which prevents the increase of mosquito numbers.

Relative Toxicities of Pesticides Used in Rice to Natural Enemies and Honey Bees (04/24)

Common name (example trade name)	Mode of action[1]	Selectivity[2] (affected groups)	General predators[3]	Parasites[3]	Honey bees[4]	Mosquitofish (*Gambusia* sp.)	Duration of impact to natural enemies[5]
Bacillus thuringiensis spp. *Kurstaki* (DiPel)	11A	narrow (caterpillars)	L	L	III	L	short
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
methoxyfenozide (Intrepid)	18	narrow (caterpillars)	L	L	II	L	short
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.

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

Armyworm (04/24)

Scientific Names: True armyworm**:** *Mythimna* (=*Pseudaletia*) *unipuncta*

Description of the Pest

The adult true armyworm is a nocturnal moth with a wingspan of about 1.5 inches and a single white spot in the middle of its buff-colored forewing. (See photo of adult Western yellowstriped armyworm for comparison.)

Females lay eggs on either rice or other grass species in or around rice fields. Eggs are laid in linear masses with the leaf tied around them in a roll, making them difficult to find.

Larvae go through 6 instar stages. Early stages are small, difficult to find, and consume very little foliage. As larvae grow, the amount they eat increases, and defoliation becomes apparent as larvae reach the fifth and sixth instars in early summer. Larvae feed predominantly at night or during cloudy days, spending the day hidden among tillers near the water level. Larvae pupate in 3 to 4 weeks during summer lodged between rice tillers. Moths emerging from these pupae may lay eggs in rice again.

Two true armyworm generations occur in rice; moths fly in spring and early summer, laying eggs in rice fields and surrounding vegetation. The larvae that emerge feed on rice foliage. A second moth flight occurs in mid-summer, followed by larvae feeding on rice foliage and panicles.

It is important to distinguish true armyworm from western yellowstriped armyworm which can also be present in rice fields. Western yellowstriped armyworm moths only lay eggs on broadleaf weeds. Eggs form a flattened mass that is covered by body scales. Larvae feed primarily on broadleaf plant species and usually don't cause economic damage to rice. The adult moth has mottled forewings and silver and gray hindwings.

Damage

Only true armyworm causes economic damage to rice. Injury is most serious during periods of stem elongation and grain formation. Larvae defoliate plants, typically by chewing angular pieces off leaves. In severe cases, all plant foliage can be consumed, leaving only a portion of the stem above the water. Defoliation greater than 25% during early summer will result in lower grain yields. During flowering and grain filling, larvae may also feed on the panicle rachis near the developing kernels causing these kernels to dry before filling. This feeding causes branches of the panicle to turn white and dangle from the panicle. Yield reductions have been documented if more than 10% of panicles are affected. Defoliation during flowering and grain filling does not typically result in reduced yields.

Management

Monitor throughout the summer to assess the need for insecticide application. Drowning and natural enemies kill many true armyworms in the rice field.

Biological Control

Many caterpillars 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 wasps *Hyposoter exiguae* and *Apanteles militaris* are the most commonly seen parasites of the true armyworm. The larvae of these wasps live within the armyworms until they emerge to form white silk cocoons on tillers and leaves.

Viral diseases of armyworms are also important natural control agents under certain conditions of temperature and humidity. Diseased caterpillars first appear yellowish and limp. After dying, they hang from plants, appear deflated, and they ooze disintegrated body contents.

For information on protecting natural enemies, see *Protecting Natural Enemies and Pollinators*.

Cultural Control

Early weed control in and around rice fields may limit the development of armyworms infestations in rice fields.

Organically Acceptable Methods

Use cultural controls and naturally occurring biological controls in a certified organic crop. *Bacillus thuringiensis* ssp. *kurstaki* is registered for use in rice, and applications generally achieve 50 to 60% mortality of true armyworm.

Monitoring

Foliar Injury

Monitor for foliar injury during late June and early July by looking for signs of armyworm feeding on leaves. Once feeding damage is observed, monitor twice a week until larvae are no longer present.

To monitor, choose a part of the field where you have observed injury. Walk into the field and inspect plants in a small area around you from the water level to the top of the leaves. Check the water surface for armyworms that may drop from the plants. Determine if 25% or more of the foliage has been removed by armyworms and if they are still present. Record your observations. Repeat this procedure every 5 to 10 feet across a transect until 10 stops have been examined. Repeat this procedure in several areas of the field to create a confident estimate of the average field condition.

Panicle Loss

Monitor for panicle loss after panicle emergence by checking for broken panicle branches that have turned white, indicating possible armyworm feeding. Be sure to differentiate this injury from stem rot, cool temperature blanking, and rat damage, all of which may cause blanking.

Once armyworm injury to the panicle is observed, take samples twice a week to determine if an insecticide application is warranted. Inspect panicles in a 1-square-foot area and determine the proportion injured by armyworms. Inspect the plants down to the water level for the presence of armyworms.

Record the percentage of injured panicles and the presence or absence of armyworms. Move 5 to 10 feet and repeat the procedure until 10 samples have been taken. Move to other areas of the field with signs of panicle injury and repeat the process until you have a good estimate of the field condition.

Treatment Thresholds

During late June and early July, consider application of insecticides only in those areas of the field with more than 25% defoliation, and where armyworms are observed. If few or no armyworms are observed, come back to check in the evening when larvae are more active. Do not spray if armyworms are not present, especially during mid to late July, because they have probably completed development.

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

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 04/24			

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

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
A.	METHOXYFENOZIDE (Intrepid 2F) Mode-of-Action Group Number[1]: 18	8–10 fl oz	4	14
B.	DIFLUBENZURON (Dimilin 2L) Mode-of-Action Group Number[1]: 15 Comments: Use permitted under 2(ee) label for yellowstriped armyworm.	4–8 fl oz	12	80
C.	*BACILLUS THURINGIENSIS* SSP. *KURSTAKI* (DiPel DF)# Mode-of-Action Group Number[1]: 11A	0.5 lb	4	0

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

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. 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 more information, see their website at www.irac-online.org/.

Aster Leafhopper (04/24)

Scientific Name: *Macrosteles quadrilineatus* (=*M. fascifrons*)

Description of the Pest

Several species of leafhoppers feed on rice plants in California, but the aster leafhopper is the only one known to be of economic importance. The adults are about 0.125 inch (3 mm) 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 overwinter in the egg stage, although nymphs and adults may be found all year. 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. Leafhoppers may complete up to six generations between spring and fall.

Damage

Although leafhoppers can be present in fields during most of the growing season, the largest numbers usually occur from early July through mid-August. Leafhoppers feed on rice plants by sucking plant fluids through their long, piercing mouthparts.

Although they are not known to be a vector of any rice pathogens in California, leafhoppers may occasionally occur in sufficient numbers to cause damage by their feeding. Injury caused by leafhoppers includes stippling, yellowing, and drying leaves. Leafhoppers prefer senescing leaves, and symptoms usually occur on older leaves first. Because leafhoppers are very mobile (nymphs jump and adults fly), an infestation generally appears throughout a field.

Management

High numbers of this pest are associated with fields heavily infested with broadleaf weeds and sedges, and with fields fertilized with excess nitrogen. Control weeds and monitor during the summer to determine the need for insecticide application. Use nitrogen rates that optimize yields. Predation can provide significant reduction of leafhopper numbers.

Biological Control

Small plot studies in rice paddies have shown a wolf spider, *Pardosa ramulosa,* to significantly reduce numbers of the aster leafhopper. For more information on practices that protect natural enemies, see Protecting Natural Enemies and Pollinators.

Cultural Control

An early and effective weed control program is an important way to prevent economically damaging numbers of leafhoppers from building on weeds and then moving to rice. Use appropriate nitrogen rates and assess the need of a nitrogen top dress.

Organically Acceptable Methods

Use biological and cultural controls in a certified organic crop.

Monitoring and Treatment Thresholds

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 apparent when walking 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 consider insecticide application when young upper leaves become infested and begin to dry.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 04/23			

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
A.	LAMBDA-CYHALOTHRIN (Warrior II with Zeon)	1.6–2.56 fl 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. Notify the mosquito vector control district personnel so that they can monitor populations of mosquitofish after use of this insecticide.			
A.	ZETA-CYPERMETHRIN (Mustang MAXX)	3.2–4.0 fl oz	12	14
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Notify the mosquito vector control district personnel so that they can monitor populations of mosquitofish after use of this insecticide.			

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

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. 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 more information, see their website at www.irac-online.org/.

Crayfish (04/24)

Scientific Names: *Procambarus clarkii* and *Faxonius* (=*Orconectes*) *virilis*

Description of the Pest

The most common crayfish in rice fields is the red crayfish, *Procambarus clarkii*, but *Faxonius virilis*, an olive-green colored crayfish, may also be found in canals and streams associated with rice fields.

Red crayfish reproduce once a year. Mating takes place anytime between spring and autumn. Eggs hatch in fall or the following spring. Young crayfish usually remain in their mother's burrow until they have molted three times. After leaving the burrow, they molt six to seven more times before reaching maturity. Adult red crayfish may live up to 2 years and molt 2 to 4 more times, growing to a length of 3 to 4 inches. Their burrows are scattered along ditches, levee banks, and in the field. Red crayfish may excavate their water-filled burrows to a depth of 3 feet. When the field is drained, they retreat to their burrows or migrate. If the burrows remain moist, crayfish can survive at least until the next season.

Damage

Crayfish are of serious concern because their burrowing and tunneling into 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. Floating leaf debris caused by crayfish feeding may resemble feeding signs caused by tadpole shrimp. Crayfish damage is distinguishable by the presence of crushed or macerated rice seed that is submerged, which 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 for several consecutive seasons.

Management

Cultural practices, such as fallowing or temporarily draining fields after initial flooding, are the key methods available for crayfish control. No pesticides are 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 the number of rice plants in a stand drops below acceptable levels (12 seedlings per square foot) during the first 2 weeks after flooding, and damage caused by crayfish is evident, temporarily draining the field will drive 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.

The decision to drain has negative aspects to consider, such as fertilizer loss, encouragement of weeds or interruption of weed control procedures, interruption of pesticide holding requirements, and the economics of irrigation.

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

Organically Acceptable Methods

Use drainage and fallowing, as described above under cultural controls, in a certified organic crop.

Treatment Thresholds

No pesticides are registered for crayfish control.

Rice Leafminer (04/24)

Scientific Name: *Hydrellia griseola*

Description of the Pest

The rice leafminer adult is a small, 0.018 inch (0.5 mm) long, olive-green fly, commonly found walking on the water surface or on rice leaves lying on the water surface, in the early-season. The females lay their elongate, white eggs singly on the upper surface of these leaves. They prefer leaves floating on the water, and 80 to 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. The 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 onto new leaves after older 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 that increases the number of leaves lying flat on the water or the length of time they are fully in contact with water will extend the period of susceptibility, especially deep-water culture or cool weather.

Seedling leaf loss, and the resulting reduction in photosynthesis, is critical at this time as energy reserves from the seed have already been depleted to get the plant through the water. The plant is usually able to grow 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 commonly found in rice fields, but because modern rice varieties grow above the water quickly, economic injury is rare. Air temperature, water temperature, plant vitality, and water depth all affect the time it takes the plant to emerge above the water. 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 numbers of leafminer parasites can be high in rice fields, they generally do not reach 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*. Parasitoids control up to 50% of the generations of leafminers that feed on grasses before rice fields are flooded. In rice, the parasitism rate in the first generation of leafminers is low, but increases to 70 to 80% in the second and third generations. Normally, a combination of parasites, predators, and high temperatures cause leafminer numbers to decline 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 of water. Under these conditions, the rice plants 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 Action Thresholds.) If the source of water is cold, such as water from some wells, you may want to establish a warming basin before the first seeded check.

Organically Acceptable Methods

Use biological and cultural controls in an organically certified crop.

Monitoring

Begin monitoring 2 to 4 weeks after planting, just after most of the rice plants have emerged from beneath the water and their leaves are lying on the water surface. Use a monitoring ring or floating plastic tubing covering 1 square foot. Take ten, 1-square-foot samples in a transect of the 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, second and third instar larvae are the easiest to detect because they create a detectable swelling in the leaf that can be felt.

Action Thresholds

If the average stand consists of 25 or more plants per square foot and an average of 20% or more of the plants have eggs or larva present, then lower the water level to a point the rice can stand upright.

If the average stand consists of fewer than 25 emerged plants per square foot and the infestation level is 10% or higher, lower the water level to a point the rice can stand upright.

When most of the leaves of the rice plants are upright, the rice leafminer will no longer cause economic losses. Consider the 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 field. Stopping the water flow into the fields may allow an adequate reduction in the water level as a result of evapotranspiration.

Rice Seed Midges (04/24)

Scientific Names: *Cricotopus sylvestris*, *Paralauterborniella subcincta*, and *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 cause 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 the water surface. Eggs hatch in 1 or 2 days and larvae form silken tubes on vegetation or the soil. The tubes are brown and have bits of debris, diatoms, and algae stuck to them. The larvae may be white, green, or reddish. Larvae feed on the material adhering to their tubes and forage from the tubes, which serve as their retreat. In the spring, the larvae go through 4 instars in 7 to 10 days. The third and fourth 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 their development, and come to the water surface where the adults emerge. 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 germinating seed. Once the seedling is several inches tall, it can usually outgrow the feeding of midge larvae, which causes irregularly-shaped holes in leaves. 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.

Seed midge and tadpole shrimp injury to leaves and roots may look similar, but the chewed areas caused by tadpole shrimp will be larger and more irregular because of the larger size of the shrimp's mandibles. Midge larvae often eat the inside of the seed, leaving it hollow; tadpole shrimp never cause this kind of injury. If the injury is caused by midges, the midge larva and tube are often still on the seed or plant at the time of examination. However, 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.

Cultural Control

Seeding should be done as soon as possible after flooding, preferably within 2 days of initial flooding. Any delay in seeding 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 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 number of plants in a stand is unacceptably low, consider reseeding. Although reseeding fields with serious stand losses has had mixed results, if done soon after seeding, 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 and reflooded after 3 to 4 days. This will discourage feeding and encourage rapid rice growth.

Draining a field has factors to consider. The potential increase in weed problems, pesticide residue problems associated with drainage water, loss of fertilizer, and irrigation costs may outweigh the benefits of midge reduction.

Organically Acceptable Methods

Drain fields, as described above, in a certified organic crop.

Monitoring

When monitoring for rice seed midge, determine the number of healthy seedlings. For example, 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 or wave action, allow a day or two for the water to clear. Examine injured seedlings or seeds with a hand lens for chew marks, the presence of midge larvae, and the presence of 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 there are fewer than 25 healthy seedlings per square foot and midge injury is evident, action should be taken. If more than 25 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.

Rice Water Weevil (04/24)

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, ditch banks, and 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, from 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 in length) 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 and headlands.

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 early July until late September. They feed on rice leaves, but by this time most plants are growing vigorously and are not harmed 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 in 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

Root pruning by larvae causes reduced yields. Plants with damaged roots may become stunted and lose yield through reduced production of tillers and panicles, or because maturity is delayed. Reduced tillering and slower growth also allow weeds to establish more readily. 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 numbers 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 improved by weed control in areas around the rice field, dry seeding, and winter flooding, depending upon current management strategies for other pests. In fields with chronic, damaging populations of rice water weevil, a preventive insecticide application 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.

Eliminating weedy vegetation on levees in spring, near the time of seeding, can reduce rice water weevil infestations in fields and subsequent larvae.

Dry and drill seeding involves seeding the dry rice field, irrigating the soil to germinate the seed, and keeping the soil moist for 4 to 6 weeks, at which time the field is flooded. By the time the field is flooded, rice plants are more tolerant to rice water weevil injury. These methods of control reduce or eliminate exposure of susceptible plants to weevil populations but would require different weed management strategies.

Winter flooding of the field, to improve straw decomposition and provide waterfowl habitat, can help with weevil control and reduce numbers 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

Use cultural control methods, including weed control and increasing field size, in a certified organic crop.

Monitoring and Treatment Thresholds

Treatment decisions for rice water weevil are primarily based on history of a particular field, proximity to weevil overwintering sites (ditch banks, riparian areas, weedy canal banks, etc.), and economics. Feeding scars can be used to confirm weevil presence. However, since egg laying can occur before plants have emerged from the water, significant injury can occur even if only a few adult feeding scars are found.

Lambda-cyhalothrin, zeta-cypermethrin, and diflubenzuron are foliar treatments that are applied after flooding. These insecticides control rice water weevil adults by disrupting their life cycle but are not toxic to weevil larvae, which is the most damaging stage to rice. Lambda-cyhalothrin and zeta-cypermethrin work by killing the adults, therefore reducing the number of eggs deposited and the subsequent larval population. Rice plants are protected by the reduction of larval numbers. Diflubenzuron functions by sterilizing adult females, causing them to lay nonviable eggs, thus reducing the number of larvae. It also is toxic to newly laid eggs that are less than 4 days old.

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

Applications of these pesticides to the 30 to 50 feet adjacent to the levees in a rice field 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 if timed correctly.

Lambda-cyhalothrin is also registered for preflood application. In areas that have a history of rice water weevil infestations, this application may be considered. Applications can be made within 5 days of flooding and light incorporation into the soil improves efficacy.

If significant injury unexpectedly occurs, clothianidin can be applied foliarly as a rescue treatment. This insecticide will kill some of the larvae feeding on roots, but its effectiveness is limited.

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

UPDATED 04/24

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

A.	CLOTHIANIDIN			
	(Belay)	4.5 fl oz	12	—

MODE-OF-ACTION GROUP NUMBER[1]: 4A

COMMENTS: May be applied preflood or postflood at 1- to 3-leaf stage with majority of plants in the 2-leaf stage. Best control results of rice water weevil larvae have been seen with the postflood application. A rescue treatment may be applied at the 5-leaf stage if an infestation isn't caught in time. This treatment only provides partial control but can prevent the majority of the crop from getting damaged.

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

B.	LAMBDA-CYHALOTHRIN			
	(Warrior II with Zeon)	1.6–2.56 fl 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 under a 24(c) Special Local Need label, which expires May 4, 2025. Apply at 1- to 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. Notify the mosquito vector control district personnel so that they can monitor populations of mosquitofish after use of this insecticide.

C.	ZETA-CYPERMETHRIN			
	(Mustang)	3.4–4.3 fl 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. Notify the mosquito vector control district personnel so that they can monitor populations of mosquitofish after use of this insecticide.

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 eggs up to 3 days old already in the plant. Apply 2 to 5 days after rice emerges above water (i.e., 2- to 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 personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. 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 more information, see their website at www.irac-online.org/.

Tadpole Shrimp (04/24)

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 6 or 7 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 soil surface. Eggs are highly resistant to drying and remain viable for several years in unflooded soil. Only eggs in the top 0.5 inch of the soil hatch, and most 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 adults in less than 24 hours. They feed on a variety of small animals and plants corresponding to their size as they grow and molt. Once the tadpole shrimp are easily visible without magnification aid, they can feed on germinating rice seeds. The somewhat transparent molt skins may be mistaken for dead shrimp.

At maturity, tadpole shrimp are about 1.5 inches long. Seven to 10 days after hatching, masses of red-orange eggs are visible in two brood pouches on the appendages of the 11th segment at the lower margin of the shield. After 30 days of flooding, most tadpole shrimp will have completed their cycle and their numbers will decrease until they disappear. If the field remains flooded, no more eggs will hatch until next year.

Damage

Tadpole shrimp cause losses in seedling rice stands in two ways. First, they may chew off the coleoptile and roots of the seedling, and uproot seedlings with their digging and feeding activity, all of which may kill the plants. Germinating seeds are very susceptible to tadpole shrimp damage; once the spike is present and roots are anchored in the soil, tadpole shrimp may not cause direct injury to rice, but they might still dislodge seedlings.

Second, their digging activities associated with egg laying and food foraging muddy the water, reducing light penetration and thereby slowing the growth of the submerged seedlings. Tadpole shrimp don't reduce stands once leaves have reached the water surface and roots are well established in the soil.

Management

Management of tadpole shrimp involves prompt seeding of the field after flooding and monitoring frequently within the first 2 weeks following seeding to determine the need for pesticide application. As an alternative, some reduction of numbers can be obtained by flooding and draining the field before flooding for seeding, such as when a stale seedbed is implemented.

Cultural Control

Most tadpole shrimp eggs hatch within 2 days of contact with water. The more time between hatching of the eggs and seeding, 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 is an alternative to chemical control. Do not drain the field until 4 to 5 days after initial flood to maximize the number of eggs that hatch. 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 for seeding may result in some shrimp hatching from previously unhatched eggs, but in lower numbers. Any soil cultivation following the drain period may bring viable, unhatched shrimp eggs to the soil surface for possible infestation upon reflooding.

Draining soon after seeding to encourage stand establishment (Leather's method) can eliminate hatched shrimp from the field. However, shrimp can survive in puddles if drying is not complete and reinfest the field when it is reflooded.

A decision to drain carries with it possible negative aspects such as fertilizer loss, encouragement of weed germination, or interruption of weed control procedures and of pesticide holding requirements, and the economics of irrigation.

Organically Acceptable Methods

Drain fields, as described under cultural controls, and apply copper sulfate in a certified organic crop.

Monitoring

Check all fields during seed germination and seedling development, but give special attention to those that had significant numbers of tadpole shrimp last year. Even if infestations were 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 that tadpole shrimp damage has occurred.

Check for tadpole shrimp frequently after seeding. Tadpole shrimp develop fast and may appear suddenly in fields that seemed free of them. In clear water, shrimp can usually be seen resting on the soil, although they may be small and difficult to see. If the water is murky or muddy, shrimp may still be seen as they come to the surface, but cool temperatures may slow their activity. A fish seine (one-eighth-inch mesh) pulled along the soil surface will reveal their presence or absence. When flooding times are long, check for tadpole shrimp presence after the field is flooded before seeding.

When monitoring for tadpole shrimp, determine the number of healthy seedlings per square foot. For example, 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 or wave action, allow a day or two for the water 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.

Count the number of seedlings found in the 1-square-foot sampling area and record the results. Take 10 samples across the check to capture variability. Note the presence of shrimp and their relative abundance.

Treatment Thresholds

An average of 25 plants per square foot are required to maximize yields. When the stand falls below 12 plants per square foot, significant yield reductions can occur.

During seed germination soon after seeding, tadpole shrimp presence warrants a pesticide application. Once seedlings have a well-developed spike and anchored roots, consider pesticide application if less than 25 healthy seedlings are found per square foot and evidence of shrimp is present in the monitoring area. If 25 or more healthy seedlings are found per square foot 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. Consider a pesticide application if the average number of seedlings drops below 25 plants per square foot.

If muddy water does not allow an adequate visual inspection of the plant stand, 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 04/24			
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.			
A. LAMBDA-CYHALOTHRIN			
(Warrior II with Zeon)	1.6–2.56 fl 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. Resistance to lambda-cyhalothrin and possibly other pyrethroids has become an issue in some areas and reduces efficacy. Notify the mosquito vector control district personnel so that they can monitor populations of mosquitofish after use of this insecticide. See label for other restrictions.			
B. COPPER SULFATE PENTAHYDRATE#			
(Chem One Copper sulfate crystals)	9 lb (for 4-in flood depth)	See label	See label
COMMENTS: Use smallest size crystal. Different water depths have different applications rates. 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. DIFLUBENZURON	4–8 fl oz	12	80
(Dimilin 2L)			
MODE-OF-ACTION GROUP NUMBER[1]: 15			
Comments: Use permitted under 2(ee) label.			

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

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. 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 more information, see their website at www.irac-online.org/.

\# Acceptable for organically grown produce.

Diseases

Aggregate Sheath Spot of Rice (07/24)

Pathogen: *Rhizoctonia oryzae-sativae*

Symptoms

Aggregate sheath spot lesions first appear on the lower leaf sheaths at the waterline 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. As the season progresses, aggregate sheath spot lesions may expand vertically, frequently reaching upper leaf sheaths of the plant and occasionally affecting the panicle.

Comments on the Disease

The disease cycles of aggregate sheath spot and stem rot are similar in several ways. *Rhizoctonia oryzae-sativae* produces dormant bodies called sclerotia that are resistant to adverse conditions and allow the fungus to persist between rice crops in the soil or infected crop debris. Sclerotia are the initial inoculum source for aggregate sheath spot disease. In spring and early summer, they float to the surface of field flood water, germinate, and may infect rice leaf sheaths at the water line. Unlike the sclerotia of the stem rot fungus, the sclerotia of the aggregate sheath spot pathogen are brown, rectangular to irregularly globose, and are much larger in size. In addition, aggregate sheath spot lesions tend to expand vertically up the stem and may reach the panicle under favorable conditions whereas stem rot lesions tend to penetrate into the culm of the stem.

On the sheath, lesions often coalesce and may cover the entire leaf sheath. Leaves of diseased sheaths turn bright yellow and then die. Under conditions favorable for the fungus (high humidity or rain), the disease may spread to the flag leaf and panicle rachises, and on rare occasions kill entire tillers. Late in the season, the fungus begins producing new sclerotia on or in diseased tissue. These sclerotia overwinter in crop residue or in soil and serve as inoculum for initial infections of subsequent rice crops.

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

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

Management

The most effective way to manage aggregate sheath spot is to limit the quantity of sclerotia carried over from one year to the next by removing or destroying crop residues. Mid-season fungicide treatments may be necessary if field monitoring indicates aggregate sheath spot lesions are approaching the flag leaf sheath.

Cultural Control

Disease cycles of aggregate sheath spot and stem rot are similar, and the diseases are managed with similar methods, i.e., use of the most tolerant 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 management of this disease. Nearly complete removal of infected crop residues by cutting rice near ground level, bailing and removal of the straw from the field may also reduce the amount of carryover inoculum in fields with high disease incidence. Moldboard plowing, crop rotation, or fallowing may also reduce carryover inoculum but may require multiple years without rice cultivation, and results may be inconsistent.

Dense rice stands may favor more severe disease development and should be avoided. Lastly, maintaining appropriate soil potassium levels is helpful, as potassium deficiency results in rice plants that are more susceptible to aggregate sheath spot disease.

Organically Acceptable Control Methods

All cultural controls discussed above are acceptable in a certified organic crop.

Monitoring and Treatment Thresholds

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 expansion 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. Apply fungicide at the early heading stage, when the first panicles start to emerge from the boot and are visible above the canopy. A well-timed fungicide treatment will reduce the severity of the disease and may prevent potential yield and quality losses.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	UPDATED 01/24			
	Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.			
A.	AZOXYSTROBIN (Quadris)	12.5–15.5 fl oz	4	28
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
	COMMENTS: 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 the two intervals is the minimum time that must elapse before harvest.

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

Bakanae (07/24)

Pathogen: *Fusarium fujikuroi*

Symptoms

Symptoms of bakanae disease first appear around a month after planting. Infected seedlings appear to be taller, slenderer, and slightly chlorotic 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 disease are often visible arching above healthy rice plants, with infected plants senescing early and eventually dying before reaching maturity. If infected plants 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 was first observed in California rice in 1999 and now occurs in all California rice-growing regions.

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

Management

The most effective means of controlling this disease is to avoid using seed that is infected with the pathogen. Seed treatment with a registered sodium hypochlorite product is effective at reducing the incidence of this disease and may be performed at either 3,000 or 1,500 parts per million (ppm) available chlorine.

For a 3,000 parts per million available chlorine solution:

1. Prepare 3,000 ppm solution of sodium hypochlorite by adding a concentrated sodium hypochlorite product to the soak water. Make sure to use the product and water volumes indicated on the label. Thoroughly mix the dilute solution. Do not add concentrated sodium hypochlorite directly to seed.
2. Check the concentration of the dilute solution to make sure it is at 3,000 ppm available chlorine.
3. Soak rice seed in the dilute solution for 2 hours.
4. Drain the dilute solution and replace with fresh water.
5. Continue soaking and draining as usual (for at least 22 hours).
6. Sow seed within 12 to 24 hours of draining. Fungal inoculum may increase exponentially on seed held in trailers longer than 24 hours after draining. If seed will be held longer than 24 hours, hold in water rather than draining to prevent the increase in inoculum.

For a 1,500 parts per million available chlorine solution:

1. Prepare 1,500 ppm solution of sodium hypochlorite by adding a concentrated sodium hypochlorite product to the soak water. Make sure to use the product and water volumes indicated on the label. Thoroughly mix the dilute solution. Do not add concentrated sodium hypochlorite directly to seed.
2. Check the concentration of the dilute solution to make sure it is at 1,500 ppm available chlorine.
3. Soak rice seed in the dilute solution for at least 24 hours. No rinse is required before sowing.
4. Sow seed within 12 to 24 hours of draining. Fungal inoculum may increase exponentially on seed held in trailers longer than 24 hours after draining. If seed will be held longer than 24 hours, hold in water rather than draining to prevent the increase in inoculum.

Common name (Example trade name)	Amount	REI‡ (hours)	PHI‡ (days)
UPDATED 01/24			

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

		Amount	REI‡ (hours)	PHI‡ (days)
A.	SODIUM HYPOCHLORITE	3,000 ppm or 1,500 ppm available chlorine		
	(Clorox Commercial Solutions Clorox Germicidal Bleach—8.25% Sodium Hypochlorite): 3,000 ppm treatment	4 gal product per 96 gal water for 2 hours	NA	NA
	Or			
	(Clorox Commercial Solutions Clorox Germicidal Bleach—8.25% Sodium Hypochlorite): 1,500 ppm treatment	2 gal product per 98 gal water for 24 hours	NA	NA

MODE-OF-ACTION GROUP NAME (NUMBER[1]): NA

COMMENTS: Preplant rice seed treatment. Do not apply undiluted product directly to seed. Drain and sow seed within 12 to 24 hours of draining, as fungal inoculum may increase exponentially on seed held in trailers longer than 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 the two intervals is the minimum time that must elapse before harvest.

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

NA Not applicable

Kernel Smut (07/24)

Pathogen: *Tilletia barclayana*

Symptoms

Kernel smut appears as a black mass of spores that replaces all or part of the endosperm 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 disease incidence is high, a dark cloud of spores may be observed coming from combines during harvest.

Comments on the Disease

Kernel smut is present in all rice production areas of California. Spores (chlamydospores) liberated during harvest fall to the soil where they overwinter. The fungus may also overwinter in or on seeds. As fields are flooded in the spring, spores float to the surface, germinate, and produce other spores and mycelial stages. At flowering (heading), secondary airborne spores may infect developing ovaries of individual open florets.

Short and medium grain varieties have lower incidence rates of kernel smut than long grain varieties. Long grain rice varieties may be more susceptible to kernel smut because their florets are open wider and for longer during flowering. Excessive nitrogen fertilization and periods of dew or light rain increase the incidence and severity of kernel smut.

At low levels, the disease has little to no effect on yield or quality. However, when incidence is high, the disease may cause lower grain yields and reduce milling quality by reducing the whiteness of milled rice.

Management

Cultural Control

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

Organically Acceptable Control Methods

All cultural controls discussed above are acceptable in a certified organic crop.

Monitoring and Treatment Thresholds

Kernel smut symptoms are not visible until grain starts to mature, around the time fields are drained for harvest. Smutted kernels are more noticeable in the early morning when dew causes the spores to ooze out of the kernel. By the time disease is evident, it is too late for any management action that may reduce its incidence. Because of this, any fungicide application will be preventive and require application prior to expression of visible disease symptoms. Fungicide applications for kernel smut will usually only occur where there is a history of significant disease incidence. The fungicide propiconazole may be effective in reducing the incidence of kernel smut when applied at the mid-boot stage, before panicles have emerged.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	UPDATED 01/24			
	Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.			
A.	PROPICONAZOLE (Tilt)	6–10 fl oz	24	35
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)			
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 the two intervals is the minimum time that must elapse before harvest.

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

NA Not applicable

Rice Blast (07/24)

Pathogen: *Magnaporthe oryzae* (anamorph=*Pyricularia oryzae*)

Symptoms

The rice blast fungus may infect and produce lesions on any aboveground rice plant tissues. The common name given to the disease depends on the tissues affected. For example, the disease is called leaf blast when lesions are observed on leaves or neck blast when lesions occur on the panicle node.

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 0.4 to 0.6 inch (10–15 mm) long and 0.12 to 0.2 inch (3–5 mm) wide. Newly formed lesions may have a white or gray-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. Lesions on a leaf can coalesce and cover large areas of the leaf tissue. Leaf blast may sometimes kill young plants up to the tillering stage. Leaf blast usually increases early in the season, then declines late in the season as leaves mature and become less susceptible. Because excess nitrogen can increase plant susceptibility to blast, leaf blast is often first observed on field headlands, where the fertilizer equipment turns, overlapping nitrogen fertilizer. Leaf blast in these areas may cause large areas of dead plants on susceptible varieties.

Leaf Collar Symptoms

Infection at the junction of the leaf blade and the sheath results in the typical brown collar rot symptom. Severe collar infection often results in the death of the leaf.

Node Symptoms

Stem nodes may be infected as the plant approaches maturity, causing the complete death of the entire 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 symptom that can be very injurious to the crop and is typically referred to as neck blast. If neck blast occurs early, the entire panicle may die prematurely, leaving it white and completely blank with unfilled kernels. Infections that occur later in the season 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 (greater than 90%), little or no wind at night, and night temperatures above 68°F. Leaf wetness from dew or other sources is required for infection. The optimum temperature for spore germination, infection, lesion formation, and sporulation is 77° to 82°F. Sporulation is greatest when relative humidity is above 93%.

Shortly after infecting the plant, the fungus produces spores called conidia. These spores disperse in the air and, under favorable conditions, may cause new infections on susceptible host tissue when there is a sufficient period of free moisture and favorable temperatures for completion of the infection process. When conditions are favorable, a single disease cycle can be completed in about a week. In addition, a single lesion can produce 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, producing a tremendous number of spores and new infections by the end of the season.

The blast fungus can overwinter from one season to the next on infected seed and diseased crop residue. Infected seed is the most important source of the fungus, followed by inoculum from overwintered and infected straw or stubble.

Management

Rice blast management in California requires implementing a variety of cultural practices: destroying infested crop residue, using pathogen-free seed, planting resistant or tolerant varieties, water seeding, continuous flooding, and avoiding excessive nitrogen fertilization. Environmental conditions in California appear to be permissive for blast development but are usually not conducive. Fungicides are available but are only needed when unusually wet conditions occur during the California growing season.

Cultural Control

Excessive nitrogen fertilization, aerobic conditions, and drought stress are all factors that can increase the risk of rice developing blast. High nitrogen rates, especially in the form of nitrate, cause rice plants to produce rapid new tissue growth that is more susceptible to the pathogen than older tissue. Extended drain periods during the season may also encourage the disease by aerating the soil which increases the conversion rate of ammonium to nitrate, and by causing drought stress to rice.

Plant certified seed to ensure that seed originates from seed fields inspected for the disease. Water seeding and maintaining a continuous flood helps reduce potential disease transmission from infected seed to seedlings. Drill seeding has a higher risk of blast disease development because of the way water is managed in this production system.

Continuous flooding limits blast development by reducing the availability of nitrate in the soil and by reducing drought stress on the plants. Avoid field drainage, especially for extended periods. Studies in other areas demonstrate that shallow water is more favorable to blast development than deeper water and blast may be more severe in shallower parts of a fields. Laser leveling of fields results in more precise water management and allows for uniform water depths throughout a field, reducing the potential for high spots that may prove more conducive to disease development.

Varietal Susceptibility

Variety M-210 is resistant to the current races of the rice blast pathogen In California. All other California varieties are susceptible. Varieties M-105 and M-209 are considered very susceptible and are not recommended in areas where blast may be severe, mostly in the northern part of the Sacramento Valley. Similarly, use the resistant variety M-210 if dry or drill seeding.

Organically Acceptable Control Methods

All cultural controls discussed above are acceptable in a certified organic crop.

Monitoring and Treatment Thresholds

In-season monitoring determines the need for fungicide treatment. Generally, a treatment for leaf blast is not necessary unless plants are being burned down in large areas of the field. However, if leaf blast is observed, a treatment during the early heading stage may be appropriate to protect panicles from neck blast. Throughout the season, examine plants in several locations throughout the field for the presence of leaf lesions and intensify monitoring as plants approach the boot stage.

Because blast spores can travel long distances, fields that show no symptoms of leaf blast may still develop neck blast during heading later in the season. If blast is present in the area, a treatment at the early heading stage may be justified to protect panicles.

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 varieties, actively sporulating leaf lesions are present, long periods of leaf wetness occur each day, and warm night temperatures persist over several days. Use a fungicide to protect panicles as they emerge from the boot.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 01/24			

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

A.	AZOXYSTROBIN (Quadris)	12.5–15.5 fl oz	4	28

MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: 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 to 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 the two intervals is the minimum time that must elapse before harvest.

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

Seed Rot and Seedling Diseases (07/24)

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

Symptoms

Seed rot and seedling diseases are most often caused by the oomycetes *Achlya klebsiana* and *Pythium* spp. Oomycetes are a group of organisms often referred to as water molds. Once classified as fungi, advances in our understanding of genetic relationships have revealed that these organisms are unrelated to true fungi and are more closely related to algae. Seed rot and seedling diseases often appear within a few days of planting. Whitish outgrowths of oomycete mycelium emerge from cracks in the seed glumes or from the collar of the infected seedling's plumule.

After a few days, the mycelium resembles a halo that radiates from the infection point on the seed or seedling. Various algae colonize the mycelium, 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 algal growth but is most likely caused by secondary invasion of the seed and mycelium 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 hindered. The typical halo of mycelium is usually evident. If infection occurs after seedlings are well established, there is generally little apparent effect.

Comments on the Disease

The diseases, which are prevalent throughout the rice-producing areas of California, are generally more severe when cool temperatures, which are unfavorable for rice growth, occur at, or shortly after, planting. Pathogens that cause seed rot and seedling diseases persist between crops of rice in the field soil. If conducive conditions for development of seed rot and seedling diseases occur, water-sown rice is often severely affected within a few days after seeding, resulting in sparse stands with fewer seedlings or reduced seedling vigor.

Management

Appropriate water management to promote rapid, uniform stand establishment is critical in reducing the impact of these diseases when conditions favor their development. Once seedlings are well established, these pathogens generally have minimal impact on the rice plants during the remainder of the season. Uneven stands caused by seed rot and seedling diseases can be partly compensated for by increasing seeding rates.

Cultural Control

Plant certified seed with at least an 85% germination rate when temperatures are favorable for rice seed germination and growth of rice seedlings (preferably above 70°F). Water-seeded rice sown into a deep continuous flood will favor disease development as deeper water slows seeding development. Laser level fields and maintain a uniform water depth of 4 inches to promote rapid germination and stand establishment without the loss of weed control often associated with draining for stand establishment. 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. In extreme cases where there is a high incidence of disease, fields may need to be drained to promote seedling establishment.

Organically Acceptable Control Methods

All cultural controls discussed above are acceptable in a certified organic crop.

Stem Rot of Rice (07/24)

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 may 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, the sclerotia float to the water surface and infect leaf sheaths of young rice plants at the waterline. New infections may continue to occur throughout the growing season.

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

Management

Manage stem rot by minimizing carryover inoculum (i.e., the number of viable sclerotia) associated with crop debris and in the soil, and by planting the least susceptible rice varieties available. Surface-applied potassium fertilizer and winter flooding of rice fields are also reported to reduce rice stem rot development. Avoid excess nitrogen, as it increases the severity of stem rot.

Cultural Control

Carry-over inoculum produced in residue of 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.

Field burning of rice residue in the fall, following harvest, is an effective method of reducing carryover inoculum. Burning destroys the existing sclerotia and residue on which sclerotia form during late fall, winter, and spring. The level of carryover inoculum is determined by the completeness of the residue destruction. Swathing at ground level and removing the straw from the field is nearly as effective as burning. Incorporation of straw and winter flooding has also proven helpful in reducing carry over of sclerotia to the following season. Tillage practices, such as moldboard plowing, that bury sclerotia and prevent them from floating and infecting the plants at the waterline reduce available inoculum levels. The level of disease reduction is dependent on the effectiveness of these practices to reduce the number of viable sclerotia that are free to float to the water surface upon flooding the rice field.

Fallowing fields for a year or two may reduce the number and viability of the sclerotia. Irrigating a fallow field during the summer encourages the decomposition of crop residue, further reducing the production of sclerotia.

In addition to managing inoculum levels, plant the least susceptible varieties of rice available. All public rice varieties currently being grown in California are susceptible to stem rot to some degree. However, longer cycle varieties like M-209 or M-211 are more tolerant than short cycle varieties like CM-101, S-102, or M-105.

Stem rot incidence and severity increase as stand densities increase; thus, avoid rice stands that are too dense. Rice stand density of 25 plants per square foot optimizes yield. A seeding rate of 150 to 175 pounds per acre generally achieves this density.

Excess rates of nitrogen fertilizer increase rice stem rot severity. Apply only the amount of nitrogen fertilizer necessary to optimize yields. Use rice tissue analysis, a leaf color chart, or chlorophyll meter readings to monitor critical nitrogen levels during the growing season to determine if there is a 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., herbicide injury) have been shown to increase infection and disease development.

Organically Acceptable Control Methods

All cultural controls discussed above are acceptable in a certified organic crop.

Monitoring and Treatment Thresholds

Currently, there are no guidelines to monitor for stem rot during the growing season; treatment decisions are made according to the disease history of a field. The need for management during the following season can be determined when the field is drained for harvest.

At drain time, examine tillers in several locations throughout the field for the presence of stem rot lesions. If 100% of tillers have lesions, a negative effect on the following year's yield or quality may occur and planning for a fungicide application the following year would be appropriate. Apply azoxystrobin at the early heading stage, when the first panicles start to emerge from the boot and are visible above the canopy. The fungicide azoxystrobin has been shown to reduce stem rot severity by 20 to 30% when applied at the early heading stage. Fungicide applications at propanil timing are not effective in reducing disease severity.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 01/24				
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.** When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.				
A.	AZOXYSTROBIN (Quadris)	12.5–15.5 fl oz	4	28
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
	COMMENTS: Apply at the early heading stage. 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 the two intervals is the minimum time that must elapse before harvest.

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Weeds

Integrated Weed Management (09/23)

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, clean farm implements when moving from field to field, and eliminate 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.

Several factors influence choice of field grade and levee spacing. 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 improved 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. Rotation crops to consider include tomato, safflower, sunflower, beans, 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 in 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, which reduces its 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 loss. 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 in the season so the herbicides can adequately cover the weed seedlings. 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 water depth management 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. Less commonly used methods include the use of a stale seedbed, and drill- or dry-seeding.

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 usually 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. Certain herbicides with long water-holding periods may make this a difficult choice to use, as water cannot be drained off the field after application.

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. Fields are drained approximately one month before harvest, to allow for combines to drive onto the field.

Stale Seedbed

Prior to planting in the spring, flush the field from March through early May. The field can be tilled or not tilled prior to flushing, but weed emergence may be less in a no-till field. Weeds will generally take 1 to 2 weeks to emerge, and the typical species that emerge are grasses (*Echinochloa* spp. and *Leptochloa* spp.) and smallflower umbrella sedge (*Cyperus difformis*). The easiest way to flush is to flood the field to 4 to 6 inches, board up the drain boxes, and allow the water to subside into the soil. After flushing, and when weeds have emerged to the 1- to 2-leaf stage or beyond, a non-selective herbicide can be sprayed, or shallow tillage can be used to control the emerged weeds. Warmer temperatures will speed up the emergence process, and cooler temperatures may delay it. This can cause planting to be postponed by a few weeks, depending on how long it takes the field to dry out enough for a tractor or spray equipment to be able to move onto the field. The method is good for herbicide resistance management.

Drill- or Dry-Seeding

The dry-seeding method is one in which the field is prepared as usual in the spring, but instead of flying the seed onto a flooded field, the seed is flown onto a dry field. The seed is then harrowed in or covered, which allows for the use of pendimethalin, an herbicide with an alternative mode of action which is not available for use in flooded fields. Typically, several flushes of water are put across the field, until the rice has emerged and established, with foliar herbicide applications made in between flushes. Fields are typically flooded around the 3- to 4-leaf stage of rice, and then a permanent flood is utilized until approximately one month before harvest.

Drill-seeding is typically utilized in the San Joaquin rice-growing area and is used by some growers in the southern Sacramento Valley as well, where crop rotation is more common. After planting rice seeds, preemergence herbicides such as pendimethalin can be used. If rice is planted deeply enough, non-selective herbicides can also be used, and applied to the emerging weeds before rice emerges. Several flushes of water are put across the field, allowing for foliar applications in between flushes. A permanent flood is typically established soon after the 3- to 4-leaf stage of rice.

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 in Common and Scientific Names of Weeds.

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 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	1–5 lsr	35–40	2	yes
benzobicyclon/ halosulfuron (Butte)	yes	yes	4	0–4 lsr	30	27/2	see comment[8]
bispyribac (Regiment CA)	yes	no	4	5 lsr–mt	0	2	yes
carfentrazone (Shark H20)	yes	yes*	2	2–5 lsr	5–8	14	no
clomazone (Cerano 5 MEG)	no	yes	6	0–1 lsr	5 (water)	13	limited
cyhalofop-butyl (Clincher CA)	yes	no	4	2 lsr–mt	0	1	yes
florpyrauxifen (Loyant CA)	yes	no	8	2 lsr to 60 days before harvest	0	4	no
halosulfuron (Sandea, Halomax)	yes	yes*	4	0–5 lsr	30	2	yes
orthosulfamuro n (Strada)	yes	yes *	4	2–4 lsr	12–24	2	yes
pendimethalin (Prowl H20)	no	no	0	0 or 4–6 lsr	5 (water) 20 (dry soil)	3	no
penoxsulam (Granite SC)	yes	yes	4	2 lsr–mt	0	2	yes
propanil (Stam, SUPERWHAM! CA)	yes	no	3	3 lsr–mt	0	7	yes
thiobencarb (Abolish)	yes	yes *	3	2–3 lsr	20–25	8	yes
thiobencarb (Bolero)	no	yes	3	2 lsr	20–25	8	yes

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]
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 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:

- 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 SUPERWHAM!)—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.

- **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 resistance 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:

- Fallow and flood the field during the summer to germinate aquatic weeds (control these weeds mechanically or use nonselective herbicides).
- Rotate to another crop to reduce the weed seed bank in the soil.

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.

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 [e.g., 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 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 = clomazone [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 particularly 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, clomazone, penoxsulam, 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 (09/23)

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* × *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 umbrella sedge (*Cyperus difformis*)

Populations of smallflower umbrella sedge 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. Foliage application of 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* spp.)

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. Using caprylic or capric acid as a spot treatment has proven effective, but the field must be drained prior to application. It is non-selective, and should therefore be used with caution, as it will damage the rice varieties as well. No other spot treatment herbicides are registered. 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 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 all the major rice-growing counties in California, including San Joaquin. 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 discovery of winged primrose willow 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.

Winged primrose willow can grow to 6 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 (09/23)

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* spp.	annual grass
winged primrose willow	*Ludwigia decurrens*	annual broadleaf

Susceptibility of Weeds to Herbicide Control (07/23)

	BSF	B/H	BIS	CAR	CLM	CYH	FLP	HAL	ORT	PEN	PEO	PNX	PRP*	THB*	T/I*	TRP
Mode of Action	**2**	**27/2**	**2**	**14**	**13**	**1**	**4**	**2**	**2**	**3**	**2**	**2**	**5**	**15**	**15/2**	**4**
ANNUAL GRASSES																
barnyardgrass	N	P	C[1]	N	C[1]	C[1]	P	N	P[1]	C	C[1]	C[1]	C[1]	C[1]	C[1]	N
sprangletop, bearded	N	C	N	N	C[1]	C[1]	N	N	N	C	N	N	N	C	C	N
watergrass, early	N	P	C[1]	N	C[1]	C[1]	P	N	P[1]	C	C[1]	C[1]	C[1]	C[1]	C[1]	N
watergrass, late	N	P	C[1]	N	C[1]	C[1]	P	N	P[1]	C	C[1]	C[1]	C[1]	C[1]	P[1]	N
ANNUAL BROADLEAVES/SEDGES																
arrowhead, California	C[1]	C	C[1]	C	N	N	C	C[1]	C[1]	N	C[1]	C[1]	P	N	C[1]	N
bulrush, ricefield	C[1]	C	P[1]	C	N	N	C	C[1]	C[1]	N	C[1]	P[1]	C[1]	N	C[1]	C
ducksalad	C	C	C	P	N	N	C	C	C	N	C	C	P	N	C	N
redstems	C[1]	P	P[1]	C	N	N	C	C[1]	C[1]	N	C[1]	P[1]	P	N	C[1]	C
sedge, smallflower umbrella	C[1]	C	P[1]	C	N	N	C	C[1]	C[1]	N	P[1]	P[1]	C[1]	C	C[1]	N
PERENNIALS																
arrowhead, Gregg	N	C	N	N	N	N	C	C[1]	—	—	N	—	N	C[1]	N	N
monochoria (pickerelweed)	C	C	C	P	N	N	C	C	C	N	C	C	P	N	C	N

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

BSF = bensulfuron (Londax)	ORT = orthosulfamuron (Strada CA)
B/H = benzobicyclon/halosulfuron (Butte)	PEN = pendimethalin (Prowl H2O)
BIS = bispyribac-sodium (Regiment CA)	PEO = penoxsulam (Granite SC)
CAR = carfentrazone-ethyl (Shark H_2O)	PNX = penoxsulam (Granite GR)
CLM = clomazone (Cerano)	PRP = propanil* (Stam, SUPERWHAM!)
CYH = cyhalofop-butyl (Clincher CA)	THB = thiobencarb* (Abolish, Bolero UltraMax)
FLP = florpyrauxifen-benzyl (Loyant CA)	T/I = thiobencarb*/imazosulfuron (League MVP)
HAL = halosulfuron-methyl (Sandea)	TRP = triclopyr (Grandstand CA)

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 (07/23)

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)

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

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
B.	BISPYRIBAC-SODIUM	0.03–0.04 lb a.i.		
	(Regiment CA)	0.53–0.8 oz	12	—

RESISTANCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, California Arrowhead
RESIDUAL: 0 days
MODE-OF-ACTION GROUP NUMBER[1]: 2 (pyridinyl-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.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
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: PPO inhibitor)
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 pinpoint 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-050007, 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.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
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: deoxy-D-xylulose phosphate 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	—

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 have 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 sprangletop
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.	FLORPYRAUXIFEN-BENZYL	0.035 lb a.i.		
	(Loyant CA)	1.33 pt	12	60

RESISTANCE: no confirmed resistance
RESIDUAL: no residual activity
MODE OF ACTION GROUP NUMBER[1]: 4 (pyridine-carboxylate: auxin mimic)
APPLICATION TIMING: 2-leaf stage to 60 days before harvest
MODE OF APPLICATION: into water, foliar spray (70% of weed foliage exposed)
COMMENTS: Florpyrauxifen-benzyl controls broadleaf weeds and sedges; it suppresses watergrass and barnyardgrass with no activity on sprangletop. Florpyrauxifen-benzyl can be applied twice in the growing season but not to exceed 2.66 pints per acre.

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

I.	ORTHOSULFAMURON	0.053–0.065 lb a.i.		
	(Strada)	1.7–2.1 oz	12	—

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.

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

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.

K.	PENOXSULAM	0.036–0.044 lb a.i.		
	(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.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
L.	PROPANIL*	3–6 lb a.i.		
	(Stam 80 EDF-CA)	3.75–7.5 lb	24	60
	(SUPERWHAM! CA)	3–6 qt	24	—

RESISTANCE: Some populations of barnyardgrass, early and late watergrass, bulrush and smallflower umbrella sedge
RESIDUAL: 0 days
MODE OF ACTION GROUP NUMBER[1]: 5 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Stam 80 EDF-CA =** early: from 3 lsr; **SUPERWHAM! CA** = later: to mid-tiller
MODE OF APPLICATION: **Stam 80 EDF-CA** = early: drained field; **SUPERWHAM! CA** = 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.)

M.	THIOBENCARB*	(Abolish 8 EC) 3–4 lb a.i. (Bolero UltraMax) 3.5 lb a.i.		
	(Abolish 8 EC)	3–4 pt	12	—
	(Bolero UltraMax)	23.3 lb	12	—

RESISTANCE: some populations of barnyardgrass, watergrasses and smallflower umbrella sedge
RESIDUAL: 25 days
MODE OF ACTION GROUP NUMBER[1]: 15 (thiocarbamate: lipid synthesis inhibitor)
APPLICATION TIMING: **Abolish 8 EC =** 2–3 lsr; **Bolero UltraMax** = 2 lsr
MODE OF APPLICATION: **Abolish 8 EC** = 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 8 EC 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.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
N.	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 (pyridyloxy-carboxylates: auxin mimic)
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 8 EC, 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.**

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
A.	BENZOBICYCLON/HALOSULFURON	0.23–0.27 lb a.i. (benzobicyclon) 0.048–0.058 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 (triketone: hydroxyphenyl pyruvate dioxygenase inhibitor, 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 a.i. Benzobicyclon) and (0.058 lb Halosulfuron-methyl) per annual growing season. Minimum water hold period for Butte is twenty (20) days.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
B.	BISPYRIBAC-SODIUM	0.0265–0.0335 lb a.i.		
	(Regiment CA)	0.53–0.67 oz	12	—
	...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 benzoates: ALS inhibitor) plus 14 (triazolinone: PPO inhibitor)
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.

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
C.	BISPYRIBAC-SODIUM	0.0265–0.0335 lb a.i.		
	(Regiment CA)	0.53–0.67 oz	12	—
	...PLUS...			

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
	THIOBENCARB*	2–3 lb a.i.		
	(Abolish 8 EC)	2–3 pt	12	—

RESISTANCE FOR TANK MIX: some populations of barnyardgrass, watergrasses, ricefield bulrush, California arrowhead
RESIDUAL: **Regiment CA**= 0 days; **Abolish 8 EC** = 20–25 days
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (pyrimidinyl benzoates: ALS inhibitor) plus 15 (thiocarbamate: lipid synthesis inhibitor)
APPLICATION TIMING: **Regiment CA** = 5–6 lsr; **Abolish 8 EC** = 5–6 lsr
MODE OF APPLICATION: **Regiment CA** = drained (but wet) field; **Abolish 8 EC** = water level lowered to reveal 70% of weed foliage

D.	PROPANIL*	4–6 lb a.i.		
	(Stam 80 EDF-CA)	5–7.5 lb	24	60
	(SUPERWHAM! CA)	4–6 qt	24	—
	...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 80 EDF-CA, SUPERWHAM! CA** = 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 80 EDF-CA, SUPERWHAM! CA** = 4–6 lsr; **Granite SC** = 4–6 lsr
MODE OF APPLICATION: **Stam 80 EDF-CA** = drained field, **SUPERWHAM! 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)	3.75 lb	24	60
	(SUPERWHAM! CA)	3 qt	24	—
	...PLUS...			
	THIOBENCARB*	3 lb a.i.		
	(Abolish 8 EC)	3 pt	12	—

RESISTANCE FOR TANK MIX: Some populations of barnyardgrass, watergrass, sprangletop, smallflower umbrella sedge, ricefield bulrush
RESIDUAL: **Stam 80 EDF-CA, SUPERWHAM! CA**= 0 days; **Abolish 8 EC**= 20-25 days
MODE-OF-ACTION GROUP NUMBERS[1]: 7 (amide: photosystem II inhibitor) plus 15 (thiocarbamate: lipid synthesis inhibitor)
APPLICATION TIMING: **Stam 80 EDF-CA, SUPERWHAM! CA**= 2–3 lsr; **Abolish 8 EC** = 2–3 lsr
MODE OF APPLICATION: **Stam 80 EDF-CA** = drained field, **SUPERWHAM! 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.	THIOBENCARB*/IMAZOSULFURON	3–3.5 lb a.i. (thiobencarb) 0.13–0.15 lb a.i. (imazosulfuron)		
	(League MVP)	30–35lb	12	—

RESISTANCE: some populations of barnyardgrass, watergrasses and smallflower umbrella sedge
RESIDUAL: thiobencarb = 20–25, imazosulfuron = 25
MODE-OF-ACTION GROUP NUMBERS[1]: 15 (thiocarbamate: lipid synthesis inhibitor) plus 2 (sulfonylurea: ALS inhibitor)
MODE OF APPLICATION: after flooding
APPLICATION TIMING: 2 lsr

	Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
	HERBICIDE SEQUENCES WITH BISPYRIBAC-SODIUM (REGIMENT)			
A.	BISPYRIBAC-SODIUM	0.0335–0.04 lb a.i.		
	(Regiment CA)	0.67–0.8 oz	12	—
	...FOLLOWED BY...			
	PROPANIL*	6 lb a.i.		
	(Stam 80 EDF-CA)	7.5 lb	24	60
	(SUPERWHAM! CA)	6 qt	24	—
	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-CA, SUPERWHAM! CA** = 0 days			
	MODE-OF-ACTION GROUP NUMBERS[1]: 2 (pyrimidinyl benzoate: ALS inhibitor) plus 5 (amide: photosystem II inhibitor)			
	APPLICATION TIMING: **Regiment CA** = 4 lsr–1 til; **Stam 80 EDF-CA, SUPERWHAM! 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 80 EDF-CA** = drained field, **SUPERWHAM! 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)	1.66 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: deoxy-D-xylulose phosphate synthase 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	—
	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: deoxy-D-xylulose phosphate inhibitor) followed by 2 (pyrimidinyl benzoate: 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			

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

RESIDUAL: **Cerano 5 MEG** = 5 days in water; **Shark H2O** = 5–8 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: deoxy-D-xylulose phosphate inhibitor) followed by 14 (triazolinone: PPO inhibitor)
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 pinpoint 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)	7.5 lb	24	60
(SUPERWHAM! CA)	6 qt	24	—

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-CA, SUPERWHAM! CA =** 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: deoxy-D-xylulose phosphate) followed by 5 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Stam 80 EDF-CA, SUPERWHAM! CA** = 1 til to full til
MODE OF APPLICATION: **Cerano 5 MEG** = into water; **Stam 80 EDF-CA =** drained field**,** **SUPERWHAM! CA** = 70% foliage exposed
...OR...

PROPANIL* (in tank mix with TRICLOPYR)	4 lb a.i.		
(Stam 80 EDF-CA)	5 lb	24	60
(SUPERWHAM! CA)	4 qt	24	—
...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-CA, SUPERWHAM! CA** = 0 days; Grandstand = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 13 (isoxazolidinone: deoxy-D-xylulose phosphate) followed by 5 (amide: photosystem II inhibitor) plus 4 (pyridyloxy-carboxylates)
APPLICATION TIMING: **Cerano 5 MEG** = Preseed to 1 lsr; **Stam 80 EDF-CA, SUPERWHAM! 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 80 EDF-CA** = drained field, **SUPERWHAM! 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	0.24–0.27 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)	1.66 oz	24	80

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

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)	0.66 oz	12	—

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 benzoates: 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)	7.5 lb	24	60
(SUPERWHAM! CA)	6 qt	24	—

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top, ricefield bulrush, smallflower umbrella sedge
RESIDUAL: **Clincher CA** = 0 days; **Stam 80 EDF-CA, SUPERWHAM! CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 1 (aryloxyphenoxy-propionate: ACCase inhibitors) followed by 5 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Clincher CA**= 3-6 lsr; **Stam 80 EDF-CA, SUPERWHAM! CA** = 2 til to full til
MODE OF APPLICATION: **Clincher CA**= at least 70% of weed foliage exposed, **Stam 80 EDF-CA** = drained field, **SUPERWHAM! CA** = 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 pinpoint 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
RESIDUAL: **Shark H2O** = 5–8 days; **Clincher CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 14 (triazolinone: PPO inhibitor) followed by 1 (aryloxyphenoxy-propionate: ACCase inhibitors)
APPLICATION TIMING: **Shark H2O** = 2–4 lsr; **Clincher CA** = 1–3 til

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

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)	7.5 lb	24	60
	(SUPERWHAM! CA)	6 qt	24	—

RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, sprangle top, ricefield bulrush, smallflower umbrella sedge
RESIDUAL: **Clincher CA** = 0 days; **Stam 80 EDF-CA**, **SUPERWHAM! CA** = 0 days
MODE-OF-ACTION GROUP NUMBERS[1]: 5 (amide: photosystem II inhibitor) followed by 1 (aryloxyphenoxy-propionate: ACCase inhibitors)
APPLICATION TIMING: **Clincher CA** = 1–3 til; **Stam 80 EDF-CA**, **SUPERWHAM! CA** = 5–6 til
MODE OF APPLICATION: **Stam 80 EDF-CA** = drained field, **SUPERWHAM! 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)	7.5 lb	24	60
	(SUPERWHAM! CA)	6 qt	24	—

RESISTANCE FOR SEQUENCE: poor control with resistant populations of California arrowhead and redstem
RESIDUAL: **Granite GR** = NA; **Stam 80 EDF-CA**, **SUPERWHAM! CA** = NA
MODE-OF-ACTION GROUP NUMBERS[1]: 2 (triazolopyrimidine: ALS inhibitor) followed by 5 (amide: photosystem II inhibitor)
APPLICATION TIMING: **Granite** = 3–4 lsr; **Stam 80 EDF-CA, SUPERWHAM! 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-CA**= drained field**, SUPERWHAM! 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	12	—
	...FOLLOWED BY...			
	BISPYRIBAC-SODIUM	0.0335 lb a.i.		
	(Regiment CA)	0.66 oz	12	—

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]: 15 (thiocarbamate: lipid synthesis inhibitor) followed by 2 (pyrimidinyl benzoate: ALS inhibitor)
APPLICATION TIMING: **Bolero UltraMax** = 2 lsr; **Regiment CA** = 4 lsr–til

Common Name (Example trade name)	Amount per acre	REI ‡ (hours)	PHI ‡ (days)
MODE OF APPLICATION: **Bolero UltraMax** = into water; **Regiment CA** = water receded to 70% exposed foliage			
...OR...			
PROPANIL*	6 lb a.i.		
(Stam 80 EDF-CA)	7.5 lb	24	60
(SUPERWHAM! CA)	6 qt	24	—
RESISTANCE FOR SEQUENCE: some populations of barnyardgrass, watergrasses, ricefield bulrush, California arrowhead			
RESIDUAL: **Bolero UltraMax** = 20-25 days; **Stam 80 EDF-CA**, **SUPERWHAM! CA** = 0 days			
MODE-OF-ACTION GROUP NUMBERS[1]: 15 (thiocarbamate: lipid synthesis inhibitor) followed by 5 (amide: photosystem II inhibitor)			
APPLICATION TIMING: **Bolero UltraMax** = 2 lsr; **Stam 80 EDF-CA**, **SUPERWHAM! CA** = 1–3 til			
MODE OF APPLICATION: **Bolero UltraMax** = into water; **Stam 80 EDF-CA =** drained field**, SUPERWHAM! 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.			

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 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.

University Of California Agriculture and Natural Resources (UC ANR) Nondiscrimination Statement For UC ANR Publications Regarding Program Practices

[Full text of USDA's nondiscrimination statement can be found at Non-Discrimination Statement, USDA]

April 2023

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