Water Management

Most California rice is produced by direct seeding into standing water with permanent flood for most of the season. Limited acreage is drill seeded and also uses permanent flood after stand establishment. The origins of this system have much to do with weed control, nitrogen nutrition and productivity, discussed in other sections.

Typically, a shallow flood is established over the field and pregerminated seed is sown by airplane into the water. The seed comes to rest on the soil surface and establishes in that spot. The water is kept on the field throughout the season except for short term drainage, permanently removing it only at the end of the growing season to prepare the field for harvest. Rice growers spend much of their time managing the water and there are numerous variations on this simple theme which makes water management more complicated than it first appears. A previous section dealt with leveling and water management structures. This section deals with water management during the season.

Purposes of Water Management

The origins of this system have much to do with weed control, nitrogen nutrition and productivity, discussed in other sections.

The general goals of water management are:

- Supply water to the crop
- Establish an optimum plant population
- Suppress weeds
- Provide for pesticide applications
- Conserve nutrients
- Protect against cold weather
- Protect water quality
- Manage salinity

Each will be discussed in the following sections.

Seasonal Water Use. Seasonal water delivery for California rice varies a great deal depending on soil type, management and seasonal length (Table 1). The average delivered use is approximaely 6-6.5 af/a, but varies from about 4 to 8 af/a, or more, depending on soil properties and water management.

Table 1. *Approximate seasonal water use by use component for rice in California*

Seasonal Water Use	Acre feet per acre
Evapotraspiration (Et)	3.1 - 3.7
Percolation/seepage	0.5 - 2.0
Drainage	0 - 2.0
Total	3.6 - 7.7

Evapotranspiration (Et, crop use, consumptive use) is the amount the crop itself takes up through the roots and transpires from leaf surfaces into the atmosphere. Et varies greatly with seasonal length, so the easiest way to save water in rice is to grow shorter season varieties. There is only a small seasonal variation in Et due to annual weather fluctuations, and some difference due to date of planting. The climatic factors important to crop use are solar radiation, wind and temperature. **Percolation** is controlled by soil texture and impervious subsoils. Most rice soils have clay and/or hardpan in the subsoil, so water does not percolate rapidly compared to deep loamy or sandy soils. If deep percolation is excessive, rice may be a poor crop choice. In New South Wales, Australia, where water shortage is chronic, rice soils are tested for infiltration rate, and if excessive, rice can not be grown. **Drainage** during and at the end of the season accounts for the balance of delivered use. This number has gone down with widespread use of laser leveling, which allows for less spillage, and mandated water holding required for pesticide use. Seepage during the season is not accounted for in this discussion, but may be considered included in either drainage or percolation. Seepage is lateral movement away from the field and occurs in all soils, but is more of a problem in finer texture soils which have high hydraulic conductivity.

Water Management Systems

Different water management system designs are used for ease of management, water conservation and maintenance of tailwater quality. Each are discussed below. For a more complete discussion, see “Rice Irrigation Systems for Tailwater Management”, UC DANR Publication 21490, available at UC Cooperative Extension Offices in the Sacramento Valley.

Flow Through System. The most common system is the flow through system, also called the conventional system. Water supplied to the topmost basin sequentially floods each successive basin as it makes its way to the lowermost basin. The water is regulated by weirs or rice boxes, described in Field Development and Tillage. Excess water is allowed to spill over the last box into a drain. By continually supplying water to the top, and allowing a small amount to spill out the bottom, with the boxes adjusted properly, the water level is automatically maintained, hence the name “flow through system.” The advantages of this system include low installation cost, ability to flush salts from the field, easy installation and removal, and adaptation to irregular slopes. The disadvantages include substantial management, difficulty in preventing excess water in lower basins, and slow response to adjustments. This system is not well adapted to holding water as required by regulations (discussed later in this section). Holding water is really contrary to the intended purpose of the system. Figure 1 is a schematic of a conventional flow through system.

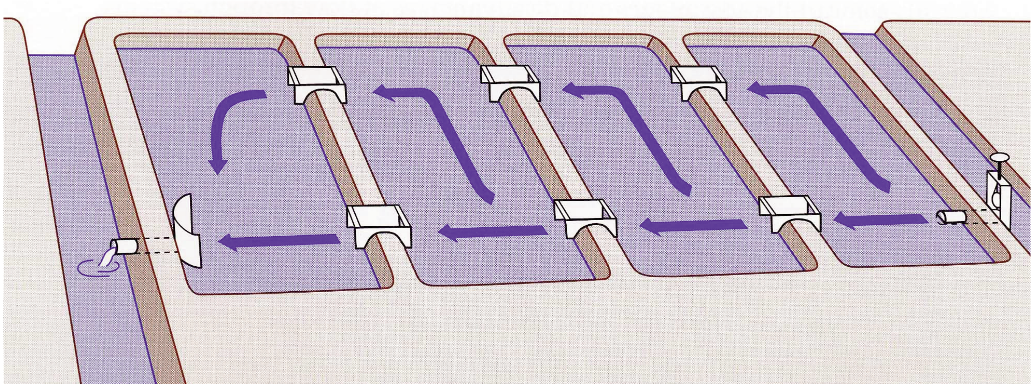

Figure 1. Conventional flow through system showing serial application of water from top (right) to the bottom of the field (left). Double box system reduces restrictions on water flow and may improve circulation. From: Hill et al. 1991.

Recirculating Tailwater Recovery System. These systems capture tailwater in a sump and pump it back to an inlet for reuse in the same or other field. They are useful for water conservation and keeping pesticide residues out of public waterways. Numerous recirculation systems have been installed although many have fallen into disuse because of maintenance and operation cost. These systems are adaptable to single fields, whole farms and whole irrigation districts. Only a few single field systems are in use. Figure 2 is a schematic of a single field with a recirculation system. The concept is applicable to various scales. All systems in use help stretch the limited supply of expensive water and allow growers to comply with less restrictive holding requirements. In-field water management is the same as for the flow through system. The major management challenge is balancing intake of fresh water with recirculated water, which is more difficult as the system increases in size. The advantages of this system are ability to keep pesticide residues out of public waterways, good flexibility of management relative to regulations, reduction of cold water effects, conservation of water, and lower water expense. Disadvantages are cost of installation and maintenance, extra land out of production, and a higher level of management.

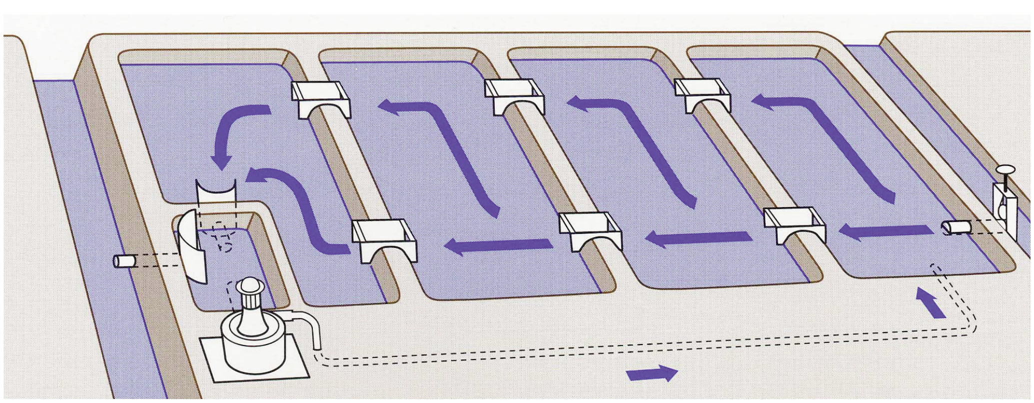

Figure 2. Single field recirculation system. This concept can be scaled up to multiple fields, multiple farms or whole irrigation districts. From: Hill et al. 1991

Static Water Irrigation System. This system was developed specifically to keep pesticide residues out of public water. The key features include multiple water inlets from a canal along the side of the field, so that each basin is irrigated in parallel but separate from the others (Figure 3). The inlet acts as the drain at the end of the season and the goal is for zero drainage. Some saline fields have conventional drains at the end opposite the intakes which allow for flushing of salts at the start of the season. Once water goes into the field it stays until the end of the season, with additional water added as needed. To accomplish this, inlet pipes are installed below grade at the low side of each basin. Each pipe has a flap valve that is opened by the pressure of inflowing water, and closes as the inflow declines, keeping water in the field. Water levels are managed by changing the levels in the supply ditch. Opposite each inlet pipe is an in-ditch weir to adjust water levels. To drain the basins, water in the supply ditch must be drained and the flaps opened. Advantages include an excellent capability for water holding, water conservation, independent control of levels in each basin, easier management and no need for a return pump. Disadvantages include higher cost of installation and maintenance of the system, land out of production, reduced flushing of salts, and unsuitability of permanent installations for rotation crops (although temporary static systems have been used in row crop areas).

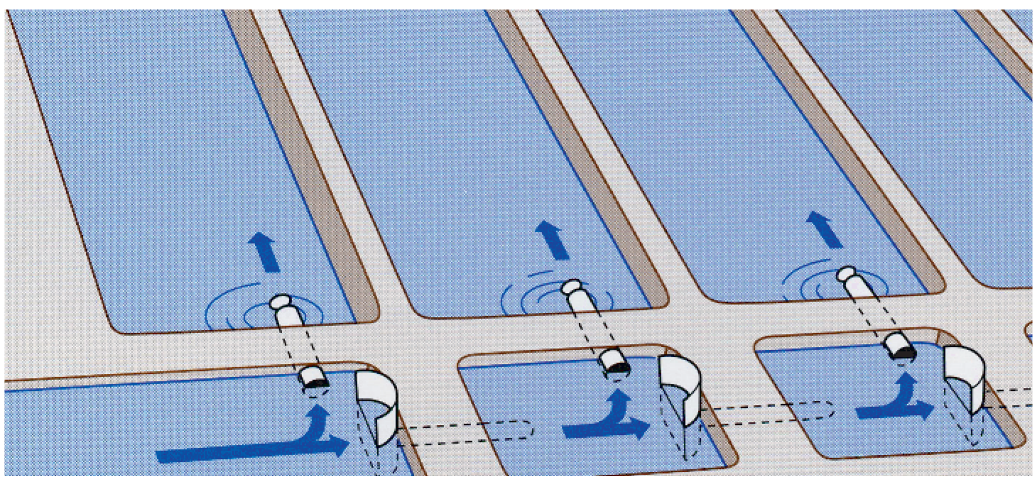

Figure 3. Static water irrigation system. From: Hill et. al.,1991

Cold Water Effects

It is common knowledge that yields are low near a cold water intake. Recent research has shown that the cold water and the associated reduction in rice productivity extend well beyond the area where the effects are readily visible. The distribution of cold water can extent throughout the intake check and bleed into the adjacent check (Figure 4). The infrared image taken in early June showed that the water temperature warmed by only about 5 degrees as it passed through the 15 acre check. The intake water temperature was 56° F when it entered the field. Plant development throughout the growing season was delayed as a result

(Table 2). Interestingly, the gradient in developmental delay was accentuated with time. For example, there was an 11 day difference in the time to first tiller between the cold and warmer parts of the check. The differential increased to 21 days by panicle initiation and to 32 days at boot. The cold water effects are accumulative. Similar relationships were observed in the yield components (Table 3). Head size and seeds per panicle decreased from the warm to the cold areas of the check. There was a corresponding increase in blanking and reduction in yield. Notice that the yield loss is not restricted to a just the area surrounding the intake box. It appears that the potential yield reduction due to cold temperature is comparable to a dose-response function.

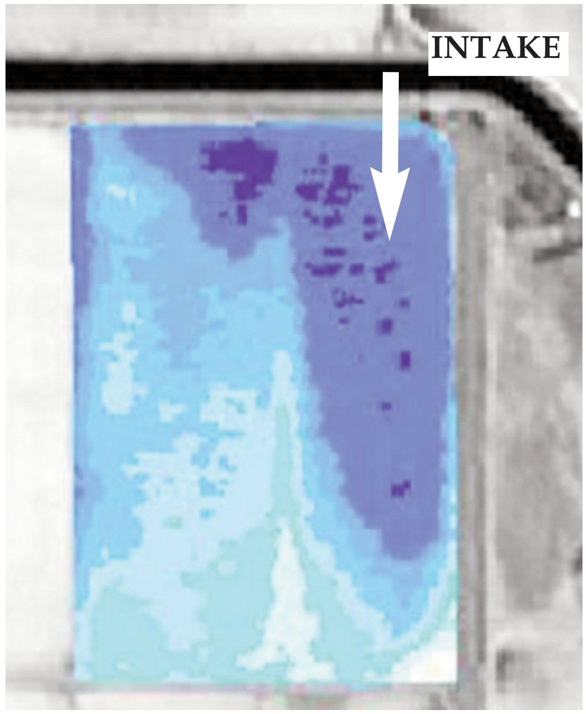

Figure 4. An infrared image showing the water temperature gradient in an intake check in early June 2001. In coming water = 56° F. There a temperature gradient of about 5° F across the check.

Table 2. *Days after planting (DAP) to reach different stage of development in a cold water intake check.*

	1st Tiller	PI	Boot	50% Heading
	-------------------------------- DAP --------------------------------			
North	43	85	120	---
(inlet)	34	69	104	114
	31	64	90	104
South	32	64	88	96

Table 3. *Yield components as effected by water temperature gradient across an intake check.*

	Head (cm)	Seeds per panicle	% Blanks	Yield (lb) @ 14% MC
North	14	0	98	402 (green)
(inlet)	13	10	53	2288
	16	45	29	5924
South	17	53	12	9138

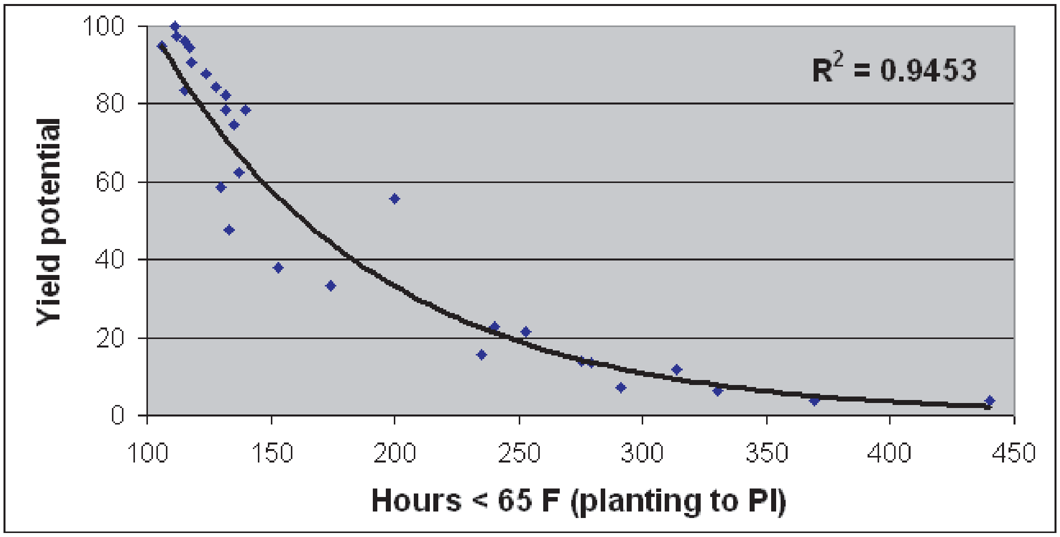

Figure 5. The potential yield reduction in rice when exposed to water temperatures < 65° F for different periods of time.

In that, the longer the crop is exposed to cold water the more pronounced the impact. Figure 5 uses a threshold water temperature of 65° to illustrate the concept. The longer the plants were exposed to water temperature of less than 65° during the day for the first six weeks the greater the yield loss. For example, only 20 percent of the yield potential was observed in the areas of the field that experienced water temperature under 65° for 250 hours (i.e. 80 percent reduction). In contrast, at 150 hours of exposure 60 percent of the yield potential was realized. If you farm ground with cold water, you may want to consider modifying the water delivery channel when laying out your irrigation system to minimize this effect.

Flow Rates

Flow rates determine the speed of initial flooding and, if necessary, reflooding. Speedy flooding is desirable for earlier planting and to prevent weeds and other pests, such as seedling disease, shrimp and midge, from getting ahead of the rice. Precision leveling, flat fields and corrugated rollers have made initial flooding quicker compared to earlier years, given similar flow rates. Increasing competition for water and greater reliance on pumps may reduce flow rates in the future, so it is important to have an appreciation for what is needed for the various stages of crop production.

Flow rate guidelines appear in Table 4, and can be used to estimate time to flood with a given quantity of water or the desired flow rate for a given size field. The calculations in Table 4 are for a delivery of four acre inches per acre, which assumes that this is sufficient to just cover the field for seeding, but not to establish a depth of flood water. About two inches are assumed to go into the soil and the balance will be on top. The amount required for initial flooding is really quite variable and depends on the amount of water already stored in the soil, the slope of the field and how the grower floods. 'Acceptable' flooding times are in the shaded area and are selected to help avoid problems that develop with increasing time. During cool spells a longer flooding period may be acceptable because growth of pests is slower. Acceptable time is arbitrarily set at 96 hours in Table 4, although it is not a disaster if the field takes a day or two longer to flood. When fields take longer than a week to flood, pest problems start to increase.

Putting it in simple terms, quick flooding requires roughly 28 gpm/a. Once a flood is established, the amount needed for maintenance is much less, a continous flow of 5 gpm/a over the course of a season. For design purposes, one should plan on a minimum of 10 gpm/a. The extra capacity allows electric pumps to operate during off-peak periods. Extremely low flow rates may require special management, such as sowing rice in sections of the field as they are flooded, or dividing fields into small units.

Table 4. *Approximate hours for initial flood for various field sizes with different flow rates. Shaded area represents acceptable time. Based on delivering 4 acre inches/a.*

	Size of Field in Acres			
GPM	**50**	**100**	**150**	**200**
500	181	361	542	722
1000	90	181	271	361
2000	45	90	135	181
3000	30	60	90	120
4000	23	45	68	90
5000	18	36	54	72
6000	15	30	45	60
7000	13	26	39	52
8000	11	23	34	45
9000	10	20	30	40
10000	9	18	27	36

Water Management Methods

Initial Flood. When field preparation is completed, boxes installed, and levee ends closed, water is introduced into the top of the field. Additional inlet sites may be used in large fields to speed the process if sufficient water is available. Flow rates determine the rate of flooding. The objective in the initial flood is to get the entire field wet as quickly as possible. In a flow-through system, this may be accomplished by blocking back water in the top basin until it is nearly covered by setting the board in the first box to hold the minimum amount and allowing the rest of the water to spill over. Repeat this basin by basin until the last one is covered. It is not necessary to establish final depth at this time, only to get the soil wet to receive the seed. It may take several days to establish the desired depth, but it is not necessary to delay seeding. Flooding from the top of the field helps flood the field faster. If the boxes are all wide open during initial flooding, the water will tend to run straight to the lowest basin, and one must work from the bottom of the field to the top. This is called back flooding and takes much more time because the tendency is to get more water than needed in the lower basins.

Establishing a Stand. Following seeding, the goal of early season water management is to establish a vigorous, healthy, weed-free stand. The management of water during this period is integrated with herbicide use and greatly affected by water supply. For example, early applied foliar materials, such as Clincher, require a drained field. Rapid reapplication of water is important for good weed control and may affect success in some areas because of low flow rate. For materials applied into the water, such as Ordram and Bolero, the goal of water management is to quickly establish a continuous flood of 4 to 5″ which provides a good compromise between rice growth and weed suppression. Shallow water (1-3″) promotes rice growth and root anchorage, but also favors weed growth. Deep water (7-8″) delays early rice growth and tillering, but also greatly inhibits grasses and smallflower umbrellaplant, the most competitive weed species. Water management for specific herbicides is discussed in the section on weed management.

Drainage for stand establishment. Many growers use a planned drain period after sowing to help improve stand establishment and/or to accommodate herbicide applications. This is a useful practice where rice has difficulty in anchoring to the soil or is easily covered or moved during windy weather. When properly used, stand density and uniformity of distribution is usually improved and concerns about the effects of wind are less. A widely used variation of this is known as the 'Leathers method,' after the grower who popularized the practice. In Louisiana water seeded rice production, the same practice is called 'pinpoint flood.' The main goal is to improve stand establishment in difficult soils. Generally, fields are completely drained immediately after sowing and the water left off until the radicle penetrates the soil and anchors the seedling. In this aerated situation, roots are stimulated to grow more than they are in a flooded, less well-aerated environment. Seedling rice responds to a surplus of air by increasing root growth, while shoot growth is less stimulated. The sequence of events is ,

- Sow rice into shallow flood;
- Drain field rapidly and completely, immediately after sowing up to two days after sowing;
- Maintain drained condition for 3 to 5 days, depending on temperature and growth of roots
- Reflood when radicle penetrates soil

It is very important this practice be used only where there is adequate water supply for quick reflooding and that the field be well leveled so that it will flood and drain quickly. If the field takes too long to drain and reflood, drought stress may kill some of the seedlings and result in a poor stand in portions of the field. Internal drains, either across the basins or around their circumference, help speed water removal and application. Timing of drainage relative to planting is also important. Waiting more than a day or two reduces the beneficial effects and may jeopardize weed control operations and timing.

Delayed Pinpoint Flood. An increasingly popular practice, stimulated by growing reliance on foliar herbicides, is to drain fields two to three weeks after planting to facilitate early herbicide application. Water may be shut off and allowed to subside rather than drain. After treatment, fields are reflooded to four to six inches and maintained. Another version of this practice is to lower water during the early tillering stage of the rice to expose weeds to foliar herbicides. This practice is primarily associated with herbicide usage and does not greatly affect stand establishment. Quick removal of water and replacement after spray application is desirable for good weed control. A prolonged drain period promotes weed growth and delayed reflooding reduces herbicide efficacy.

Permanent flood, water depth effects. Permanent flood should be established as soon as possible after sowing. The sooner it is done, the more beneficial impact it will have on weed management. Once established, permanent flood is maintained throughout the rest of the season. Maintain a steady depth of 4″-5″ through maximum tillering and avoid taking water off the field.

The goal of the permanent flood is to maintain steady pressure on weeds and optimize rice growth. Rice growth response to various depths is demonstrated in Figure 6. For example, rice growing in shallow water (1-2″) begins tillering faster, and reaches a higher maximum tiller number than rice growing in medium (4-5″) or deep water (7-8″). Rapid establishment of plant cover is the main reason many growers prefer shallow water early in the season. Ultimately, the final tiller number is similar at all depths within this range because excess tillers developed in shallow water die off to a level that the plant can support. Leaf development and plant size (biomass) follow a trend similar to tillering. However, rice plants in deep water are taller throughout the season and mature earlier compared to rice growing in shallow water. Growth of rice in deep water suggests it is under stress which slows growth for the first half of the season, even though final growth parameters, except height and maturity, are similar at all three depths. Yield in field scale trials comparing different depths within the range of 2″ to 8″ was the same across all depths.

Most growers are reluctant to accept slower crop development and increased management required for deeper water and prefer lower water to ensure that plants perform at their optimum, particularly when environmental conditions are adverse. Some soils, such as alkaline and saline soils, are already stressful to the crop, and deep water is not advisable. In addition, levees holding deep water are more subject to wind damage. Use of thiobencarb in deep water is also not advisable. However, some growers have found value in deeper water, 5-7″ through tillering, for better weed control where soil conditions permit it. One should avoid very shallow water, 1-3”, because weed control will be very difficult.

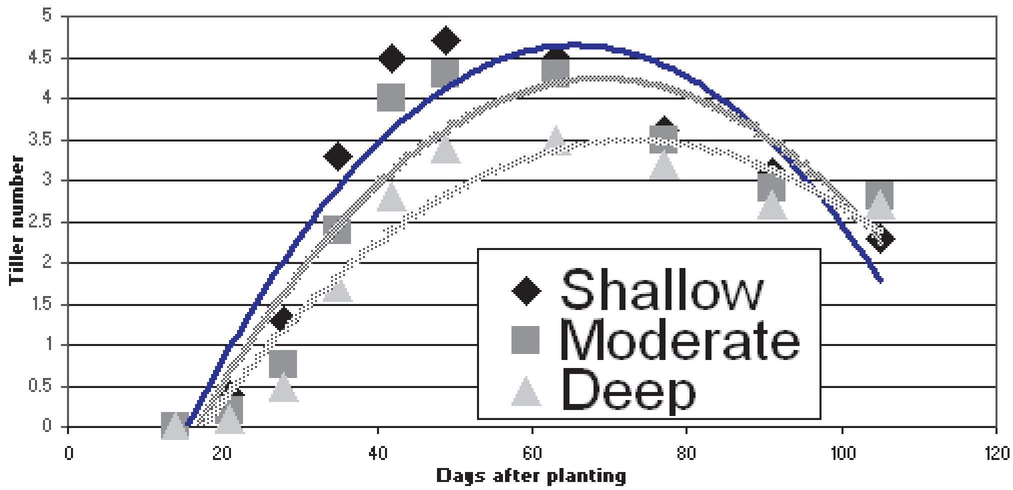

Figure 6. Tillering of M-202 rice at three water depths held season long, 1986. (Williams et al. 1994)

Blanking Protection. Blanking occurs when pollen is damaged by cool temperature. Since rice florets are primarily self-fertilized, the loss of pollen is not usually replaced from other nearby florets, so a kernel does not develop. UC research in the early 1970's showed that the position of the panicle when it is sensitive to cool temperature is low in the stem, partially underwater. This is usually 10-14 days before the panicle emerges, and when the collars of the flag leaf and the penultimate leaf are aligned. The sensitive period lasts for about a week for any individual panicle, and for about three weeks for a field. As air cools during the night, the air temperature within the canopy also drops. However, the water resists change and its temperature takes longer to drop. This difference in air and water temperature can provide a critical source of heat to protect the rice heads from cool temperature damage. The change in air and water temperature at different heights above the soil is shown in Figure 7. At 8 pm, the air and water temperature are similar, but by 6 am, there is a large difference. The amount of difference increases with depth of water and lower temperature. Growers can take advantage of this natural heater by increasing the water 7 to 21 days

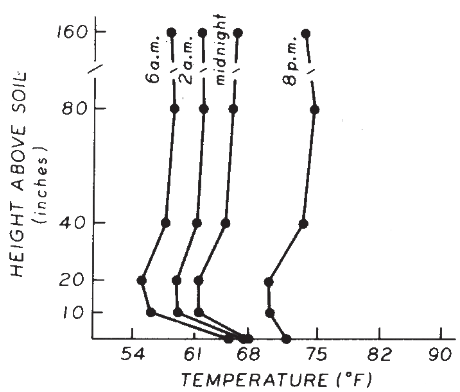

Figure 7. Temperature profile of a rice canopy. Water depth is 6". From: Board and Peterson 1980.

before heading, which begins roughly at 70 days after planting for M-202. The water should be as deep as the levee system in the field will allow, but at least 8". This depth will partially cover the developing panicles and help protect them from the cooler air above. Since tillering is complete, water depth will not affect growth.

Pre-harvest Water Management. Preharvest drainage requires a compromise between the conflicting needs of harvesting equipment and crop ripening, although certain risk factors can be identified to guide the process. As with many other management practices, the grower's task is to optimize drain timing.

Typically, water is removed two to four weeks before anticipated harvest date. See the section on varieties for information on seasonal length. Heavy harvesting equipment requires a firm soil so it won't cause deep ruts and/or get stuck in mud. Mud during harvest not only decreases efficiency, it may cause serious damage to valuable equipment and rut the field. The exact timing, to ensure a firm soil, depends on,

- surface drainage-accurately leveled fields drain more completely than those with potholes;
- internal drainage of the soil-soils with deep profiles usually drain quicker although soils with very high clay, such as Willows clay, are slow to drain;
- physiological activity of the rice-plants that remain greener will use more moisture than senescent plants; Quadris sprayed fields tend to hang on longer and affect drain time;
- and climate during the drain period--high temperatures and north wind increase evapotranspiration.

Integrating these factors is more art than science and there is no substitute for experience with a particular field. In the end, you want a firm, but not dry, soil surface on which to run harvest equipment. In recent years, many growers have switched from half track and full track equipment to rubber tires, increasing the importance of a firm soil at harvest.

As important as making sure the ground is dry enough to support equipment is to make sure it is moist enough to finish the crop. Premature drainage will impede ripening and result in more chalk and light kernels. In addition, research has shown that milling quality is improved if the water is left on longer, including up to the time of harvest! Since harvesting in the water is not a practical option, the grower has to decide when to drain to optimize ripening. Rice does not ripen uniformly, especially in different parts of the field, so assessing the entire field is important. The same factors that govern how fast the soil drains pertain to the moisture supply for ripening. Some rough guidelines for determining when the crop is sufficiently ripe to tolerate drainage are,

- grains have filled from the top to the bottom of the panicle;

- color has changed from green to golden;
- tip kernels have become hard;
- lower kernels will have soft dough but not milk.

Water Stress

Drought stress sometimes occurs when a pump shuts off or on the high side of a poorly leveled field. Some organic growers also use mid-season drainage for weed control which induces drought. The rice varieties used in California are generally very intolerant to water stress. Leaf expansion, photosynthetic activity, net carbon dioxide fixation, and translocation of photosynthetic products are all reduced during drought stress. While rice can grow under irrigated conditions, with soil moisture below saturation, it will usually not yield as well as continuously flooded rice. Signs of water stress include leaf-rolling, leaf-scorching, impaired tillering, stunting, delayed flowering, spikelet sterility, and incomplete grain filling (Yoshida 1981). Drought avoidance is important during expansive growth beginning in the early vegetative stage, the degree of injury from which is related to the intensity and duration of the water deficit (Hsiao 1982). However, if not severe, addition of water usually leads to complete recovery. The most drought sensitive growth stage is floral development, starting with microsporogenesis through heading (Boyer and McPherson 1976). This leads to blanking and the crop cannot recover from it. During ripening, premature removal of water may lead to incompletely filled kernels and lower test weight.

Maintaining Water Quality

Since rice tailwater ultimately flows back to public waterways, growers must maintain its quality by using appropriate practices. The definition of quality includes degradation of water from pesticide residues, nutrients, sediment and other suspended or dissolved materials. The exact levels that are considered degrading to quality are determined by government regulations. Currently, the rice industry is not required to use special practices regarding suspended sediments or dissolved materials, although this could change in the future as scrutiny increases and water quality criteria tighten. Water leaving rice fields generally has low levels of suspended sediment and dissolved nutrients. In the 1990s, copper in tailwater was studied in response to questions about high copper levels in Delta waters. Very little copper was found in tailwater, mostly in bound organic forms. There is current interest in organic carbon in rice tailwater although no management practices are proposed. The importance of organic carbon in water includes an increase of microorganisms feeding on the carbon which depletes oxygen in streams, and potential formation of toxic carbon compounds.

The primary water quality concern of the California rice industry is residue from pesticides applied to the fields, particularly the herbicides thiobencarb and molinate. Long term water holding following application is the primary management method. This allows for degradation of pesticides within the field. This approach has been highly successful in reducing the level of rice pesticides in public waters. A regulatory program has been in place since the 1980s and growers have incorporated the concepts into their programs. Future water quality considerations will likely involve more intense management of water and restrictions on drainage and seepage.

The current program was developed by the Department of Pesticide Regulation and adopted by the Regional Water Quality Control Board. It is reviewed annually. A summary of water holding requirements for the 2009 season is given in Table 5. In addition to the state regulations, each rice pesticide label has additional information regarding water holding.

Table 5. *2009 water holding requirements for rice.*

Type of System	Specified Holding Period in Days		
	Bolero 15-G	Bolero UltraMax	Abolish SEC
Hold on Field	30	30	19
Ponding or Tailwater return	14	14	14
Multiple growers/district recirculation system	6	6	6
Release from closed recirculation system	19	19	19

From: California Department of Pesticide Regulation, Rice Pesticide Program for 2002.

Table 6. *2009 labeled water management requirements for pesticides not included in the Rice Pesticides Program*

Common Trade Name	*Active Ingredient*	*Water-Hold Time*	*Provisions*
Insecticides			
Dimlin® 2L IGR	Diflubenzuron	14-days	None
Mustang® 1.5 EW Insecticide	(s)-cypermethrin	7-days	None
Warrior® Insecticide	Lambda cyhalothrin	7-days	None
Fungicides			
Quadris® Flowable Fungicide	Azoxystrobin	14-days	None
Stratego® Fungicide	Trifloxystrobin/Propiconazole		
Herbicides			
Shark® Herbicide	Carfentrazone-ethyl	5-days static/ 30-days release	Less if closed system
Cerano™ 5 MEG	Clomazone	14-days	None
Clincher™ CA	Cyhalofop-butyl	7-days	None
Whip® 360 Herbicide	Fenoxaprop-p-ethyl	14-days	Applies to use of irrigation water to other crops
Stam™ 80 EDF	Propanil	7-days	Less if closed system
Grandstand™ CA Herbicide	Triclopyr TEA	20-days	Less if closed system

Seepage management is a recommended practice to contain the residues that may flow in seep water to drains. Seepage is the lateral movement of irrigation water through a rice field levee or border to an area outside the normally flooded production area (Roberts et al. 1998). It is not currently regulated, but recommendations include,

- Block any exits of seepage ditches that may drain into agricultural drains;
- For severe seepage, pump the water back into the field or fallow land;
- Inspect levees for crayfish or rodent damage, and repair any leaks;
- Build levees in the fall so they will compact;
- Build levees with enough soil moisture for good compaction;
- Avoid building levees with excessive straw;
- Compact levees with a tracklayer;
- Control crayfish and rodents.

Managing Salinity

Rice is particularly sensitive to salinity during the seedling and pollination stages. While most irrigation water used on rice in California has low salt (<0.7 dS/m), some water sources that include drain and well water can go much higher (Scardaci et al. 2002). Sacramento River water is 0.13 to 0.37 dS/m and is very low salt.

The type of irrigation system and pattern of flow also affects salinity. In static and conventional systems, salinity increased with distance from the inlet. Water with much lower salinity will result in higher salinity as salt accumulates and moves through the field so that lower basins typically have higher salinity, which peaks during holding periods. Yield reductions were associated with salinity of >1.9 dS/m .

Management of salinity is fundamentally by dilution with water that has a lower salinity, although it may not be easy to accomplish. Addition of fresh water, even if it is somewhat saline but below the salt level in the field, accompanied by draining from the lower end, will dilute the problem areas. With continuous flow, salt won't accumulate. With water holding restrictions, however, draining salty water may be difficult without a fallow field or a district drain. Growers using saline water should avoid using herbicides that require long term holding so they can flush the field during the early part of the season.