Planting and Stand Establishment

Tillage

A great deal of rice production costs, time and effort are related to tillage. About 60% of the equipment investment expense and 15% of the growing costs are for tillage operations (Williams, 2001). So, it is important to have a good grasp of the objectives of tillage, which include,

- Drying of soil
- Loosening of the soil to allow for subsequent land smoothing operations and application of preplant fertilizer
- Forming a uniform seedbed free of large clods
- Destruction of growing weeds
- Aeration to hasten decomposition of residue
- Release of nutrients in organic matter
- Burial of crop residue to reduce disease inoculum and keep floating residue from accumulating and suppressing crop growth

Once these objectives have been achieved there is little reason to continue to work the ground. Typical tillage involves one or two passes with a chisel plow, and one to three more with a single disc harrow. Sometimes soil will be very cloddy and require extra work to break down large clods. The final seedbed in a rice field does not have to be as fine as for direct seeding of row crops, and by comparison is quite coarse. More important is the uniformity of the surface so that there are no off-grade high and low spots and large clods do not protrude from the water after flooding.

Chiselplow. Many growers rely on heavy chiselplows as the first ground breaking operation in the spring. The chisels are usually mounted on a spring or have a coil configuration which helps lift the soil. Some are rigid chisels and penetrate slightly deeper and produce a more cloddy surface. Chisels have a lifting action and the objective is to loosen, aerate and dry the ground. Drying is important to facilitate subsequent ground work, to allow air to get in pore spaces, and to avoid destruction of soil structure which may be damaged by heavy equipment working on wet soils. Subsequent operations depend on dry soil, so it is important to allow adequate time for drying before

Figure 1. Fall chiselplow operation incorporating rice straw (left), and typical chisel shank (right).
proceeding. A chisel shank and chiselplow operation are shown in Figure 1.

**Discs.** Heavy single offset discs are usually used after chiseling to work deeper and mix crop residue with the soil. Such discs have a rigid mainframe that supports two gangs of disc blades that operate at an angle to the direction of travel so that they penetrate the soil and roll it (Figure 2). The front gang is set to cut in the opposite direction of the rear gang. The round blades may vary from 28” to 32,” and may have smooth or scalloped edges. This operation is important to continue drying the soil, facilitate soil contact for residue decomposition and to prevent residue from rising to the surface where it may be a problem. One or two passes with each implement is usually necessary. These operations also destroy growing weeds to prevent them from getting a head-start on the crop. As air enters the pore spaces, organic matter begins to decay more rapidly which results in conversion of nutrients from their organic forms to mineral forms, called mineralization. Greater availability of nutrients, particularly nitrogen, is an important benefit of tillage. Rice soils which never dry and aerate are generally less fertile.

**Tillage for drill seeding.** The seedbed in a drill seeded field is prepared as for water seeding except the goal is a finer, well-packed seedbed to precisely control seed depth. Alternatively, some growers have occasionally drill planted if the soil surface is not rutted from the previous harvest. This involves drilling directly into the field without otherwise tilling the soil and is referred to as ‘no-till.’ Winter vegetation may be destroyed with herbicides. Growers use no-till to reduce tillage costs, get an earlier start and discourage weeds which tend to be less severe when the soil is not disturbed. A heavier, specialized drill is usually needed to cut through residue and packed soil.

**Plowing.** Deep tillage with a moldboard plow or disc plow is less commonly used because of higher cost and disturbance of the smoothness of the field. However, plows have regained some popularity for residue management. Plows are useful because they invert the soil and can completely bury residues and weed seeds. But, they also leave the ground very rough and possibly out of level. Since they cut deeply, plows are not appropriate in fields with shallow surface layers or calcareous subsoils.
where they may bring soil chemistry problems to the surface. Plowing is more common in rowcrop areas but some growers are plowing about every third year in rice-only areas. Over the long term, deeper tillage will deepen the plow layer and should benefit soil fertility and root growth.

**Depth of Tillage.** Tillage depth should be consistent with the overall objectives of land preparation-drying and loosening the soil, and burying residue. Typically, 6 to 8” is sufficient. Some shallow soils limit tillage depth while others have deeper topsoil. Rice roots are shallow and do not respond to deep tillage as some deep rooted crops do. The supply of nutrients is more important than depth. Deeper soils tend to have a thicker layer of nutrient rich soil, so rice on such soils often performs better compared to shallow soils.

**Spring Residue Management.** Most straw management work is done in the fall, but despite best efforts, there is often abundant straw in the typical spring seedbed which must be managed. Good practices in the fall will help spring operations, particularly chopping, which assists with incorporation and decomposition. Uncovered straw will float and drift into corners, edges or high spots and reduce stand and increase disease so a goal of spring work is to cover as much straw as possible. Chisels and discs will partially cover straw, but have the tendency to also bring some back up again. The only remedy is to do extra ground work if there is abundant straw still on the surface. It is probably not economical to continue to work the ground past one or two extra operations.

**Land planing.** A land plane is simply a long, rigid rectangular (four wheels) or ‘A’ frame (three wheels) in the center of which a scraper blade or bucket is set (Figure 4). As the operator pulls the plane across the field, soil fills the bucket and simultaneously spills forward out of the bucket, creating a churning action that breaks up the clods, improves their uniformity and fills in ruts from previous groundwork. The depth of cut of the scraper blade can be adjusted, but typically cuts no more than an inch deep into the tilled soil. The smooth surface is ideal for fertilizer application because it facilitates uniform depth of placement. Typically, one pass with a plane is sufficient, although some growers use a second pass at an angle to the first. Landplaning is a relatively slow and expensive operation. Planing only smooths the surface, but is not a substitute for leveling. However, land planing is important for maintaining integrity of the leveling job and to fine tune it for the current season. With prevailing shallow water management, off grade spots and large clods represent potential weedy sites. Planes do not work well in wet soil since the soil must flow freely in and out of the bucket. Land planing packs the soil and if it is moist, will stimulate early weed
growth. Therefore, once the field is planed, subsequent operations must be done promptly. Preplant fertilizer is usually applied to the smoothed soil, although some growers plane after fertilizer application.

**Corrugated Rollers.** Heavy corrugated rollers are commonly used as a final field operation to eliminate large clods and pack the soil, providing a more uniform surface compared to a disced seedbed (Figure 5). To some extent, the corrugations help keep seed evenly distributed. Seed planted in corrugated fields often settles into the bottom of the groove, resembling drill seeded rice. Corrugated rollers are 15’ to 24’ wide and have ridges at 6” to 7” spacing around their circumference. This tool is consistent with shallow water management because large clods are either broken or pressed down in the seedbed. Liquid and dry fertilizer and herbicide applicators may be attached to the roller frame and allow growers to perform simultaneous operations. Rollers require dry soil for good operation. Moist soil will cake on the surface and clean corrugations will not form. Corrugated rollers are fairly cheap to operate unless additional operations are combined with them. These combined operations require additional controls in the tractor cab and a skilled operator is important.

**Alternative Systems.** The seedbed in a drill seeded field is prepared as for water seeding, except the goal is a finer, well-packed seedbed to precisely control seed depth. A smooth roller may benefit this operation. Rarely, growers may drill directly into the field without otherwise tilling the soil, called ‘no-till.’ Growers use no-till to reduce tillage costs, get an earlier start and discourage weeds which tend to be less severe when the soil is not disturbed. A heavier, specialized drill is usually needed to cut through residue and packed soil. This is rarely done because there is often some damage from harvesting or spraying equipment that must be repaired. Of current interest is dry seeding, which involves sowing unsoaked seed on the soil surface and shallowly covering it with soil. A corrugated roller or light harrow may be used for this.
**Seed Soaking**

Most California rice fields are sown with soaked, pregerminated rice seeds. Soaking accomplishes two purposes. First, water replaces air inside the seed coat so that the seed is less buoyant and sinks more readily, helping to keep the seed from drifting and ‘bunching.’ Second, germination processes are started so that the seed will have a headstart when it is planted compared to dry sown seed. A flooded rice field is an inhospitable environment, habitat for numerous pests and competitors of rice seed. During soaking, vital physiological processes begin which are precursors to growth. Allowing the most vulnerable period of a seeds first hours of growth to take place in the relatively benign environment of a soaking tank helps assure its success in the field. Dry seeds sown into water tend to more susceptible to midge, shrimp and disease attack. Research has shown that the duration of soaking is roughly equivalent, in terms of plant growth, to sowing earlier by the same amount of time as the soaking (Grigarick, et. al. 1984). Pregerminated seeds sprout more quickly and anchor their roots into the soil, reducing the time of exposure to the different pest and environmental problems that affect early seedling development. The soaking tank helps prepare the seed for the rigors of the cruel world of the rice field.

**Water absorption and growth.** A rice seed absorbs moisture rapidly once it is placed in water, and continues to increase its water content well beyond the time when it is ready for sowing (Figure 6). Early growth processes were observed at a steady 68°F, somewhat cooler than the typical environment of a rice soaking tank (Williams, 1986). Water was absorbed rapidly during the first three hours and then the rate of absorption declined to a relatively steady rate there after. At 12 hours after imbibition the seeds had a ‘hydrated’ look and moisture content of over 25%, about doubling water content. The first visual sign of growth was swelling of the embryo and a change to a translucent character at 42 hours and moisture content of 36.5%. By 48 hours, the embryo was just beginning to split the hull and by 60 hours the first shoots were breaking through.

**Soaking.** Soaking is typically done in steel bins (Figure 7), with dimensions of approximately 48” wide, 48” deep, and 51” high, and a volume of 62 to 64 cubic feet. The bins have indents at the bottom for forklifts to lift, invert and dump the seed into trucks. A full bin will hold up to about 2300 lbs of dry seed, and contains about 230 gallons of water (seed just
covered). In other words, ten gallons of water is required for every hundredweight seed, plus an additional gallon/cwt as the seed absorbs water. The exact amount of water for initial filling depends on the grain type, with medium grains requiring slightly more water than long grain. The bins are usually fitted with drains so that water can be removed for drainage.

Some seed soaking is also done in the same trucks which deliver the seed to the airstrip before planting. The advantage is reduced handling, no need for bins or forklifts and less labor. The disadvantage is the large volume will generate more heat than small bins if seeding is delayed, and it is difficult to refill and cool the seed. Sprinklers are sometimes put on the trucks for cooling if seeding is delayed.

The metabolic activity of growth creates heat which will accumulate in the enclosed soaking bin. High outside air temperature will increase the rate of heat accumulation. As temperature rises, respiration rate increases, up to about 90°F, and then starts to drop off. Oxygen levels also decline as the seed oxygen demand increases. If soaking proceeds too long, the combination of high, sub-lethal temperature and low oxygen will cause poor seedling vigor and delay in stand establishment. Loss of seedling vigor may lead to stand loss from pests and weather damage. Lethal temperatures for wet rice seeds have been variously reported from 104 to 113°F.

Damaging temperatures can easily be reached if soaking is not done properly, and is regulated mainly by time of soaking/drainage. Recommended soaking guidelines are 24 hours in the soak water and 24 hours of draining, for a total pregermination time of 48 hours. Seed does not have to remain in the water for the entire duration of pregermination for early growth to begin. The seed should be sown promptly after 48 hours to avoid heat accumulation and oxygen depletion. These guidelines are flexible and many growers vary significantly from them. There is some safety built into the guidelines. But real problems with heat begin when 48 hours is greatly exceeded. When sowing is delayed by north wind or flooding delays, growers should attempt to cool the seed by refilling the soak tanks with fresh, cool water. Trucks with seed in them should be taken to a shady area, tarps removed and sprinklers put on top.

**Planting**

Adequate drainage is necessary to prepare the seed for sowing. During drainage, while pregermination continues, excess moisture drains away so the seed will more easily flow from the trucks and the aircraft spreaders. Poorly drained seed will stick together and resists flowing, resulting in poor distribution in the field.

Direct sowing requires soaked seed be flown directly into the flooded
field so that it comes to rest on the soil surface. It is important that the seed remain on the soil surface. Seed that is buried more than a centimeter in the soil will have low vigor or won’t germinate because of inadequate oxygen. Rice seed needs a ready oxygen supply to sprout. Flood water replaces air in the soil and greatly reduces diffusion. Figure 8 shows how oxygen levels at various points in the water and soil differ. Research by UC scientists and others showed that the oxygen level in a rice field drops to near zero within 6 to 10 hours when a dry soil is flooded. In addition, the flood water reduces oxygen diffusion into the soil by a factor of over 10,000 times. (Patrick and Mikkelsen, 1971).

The top centimeter of soil contains some oxygen which declines rapidly with depth. Seed buried in this layer will have reduced vigor but some chance of survival, particularly if they are sprouted when buried.

**Stand assessment.** In a California study yield was unaffected by the number of seedling plants over an established plant population density range of 12 to 46 plants/ft² (Miller, 1991). Minimum seedling population for maximum yield is dependent on so many factors—sowing method, water management, planting date, variety, soil type and others—that it is difficult to give a precise number. What may be acceptable in one situation is not in another. A general guide is to have 10 to 20 vigorous plants per foot. If a field has significantly less than ten per foot, it may not perform well.

Assessment of the stand soon after sowing is therefore very important to ensure that pests (diseases, midges, shrimp) and burial have not reduced the stand to an unacceptable level. Refer to the Variety section, Seeding Rate, Table 9, which gives seeds per foot at different sowing rates. In cool weather rice will germinate and grow slowly and less uniformly, and as temperatures warm the reverse is true. Optimum temperatures for germination and early seedling growth are in the range of 77 - 94°F. Minimum temperature for germination is 54 - 56°F, and maximum temperature is 104°F. Seedling pests also respond to temperature, with diseases tending to be more damaging in cool weather, partially a result of poor growth and prolonged exposure of the rice. Shrimp and midges, on the other hand, tend to be more severe during warm periods.

Early identification of insufficient stand is essential to successful reseeding. The longer the delay, the less the success. Stand evaluation must be
made within the field. A useful tool for looking at small plants is a sampling cylinder, Figure 9. Carefully push it slightly into the soil to avoid stirring up sediment and observe the condition of seeds within the cylinder. By making it a known size, such as one square foot, one can make a count of healthy seedlings. Another version is a box fitted with a Plexiglas bottom. By pressing the box to the soil surface, seeds can be easily seen without mud obscuring them. Close examination of individual seedlings is necessary so it is very helpful to have a hand lens. More information on stand establishment pests can be found in the sections on diseases and invertebrates.

Wind burial can reduce plant population and bunching can leave large open areas, both of which may necessitate reseeding. Assessing a buried or bunched stand is difficult. Buried seeds may eventually succeed but finding them is difficult. A coarse screen with mesh just smaller than the seed can be fitted in a frame and pulled across the surface. Sluicing with water will reveal the seed, although it does take some work. A bunched stand leaves many areas under populated while other areas have too thick a stand.

**Reseeding.** Once the decision to reseed has been made, identify and manage the possible impediments to success. Over the first few days of flooding many organisms establish in the field—algae, crustaceans, insects, microorganisms—some of which are potentially damaging to the rice. In addition, a layer of detritus composed of dead algae and diatoms may form on the soil surface which can deter root growth. To the extent possible, one should manage these problems with appropriate measures. As stated above, early diagnosis is important and the most important component of successful reseeding. Depending on the density of the stand, the reseeding rate can be from 50 to 100% of the original rate. Normal soaking procedures should be used so the new seed will start quickly. Depending on the time difference between first and second seeding, one may consider using an earlier maturing variety of the same market category to help with uniform maturity. Soaking of the new seed should be done according to standard guidelines (24 hours soak/24 hours drain). The new seed will perform better if the field is drained. However, drainage must be balanced against the potential loss of weed control.
Rice seed has dormancy inhibitors in the hull when it is first harvested. Currently used varieties naturally lose their dormancy with time and it is not necessary to do any special treatments prior to planting at normal dates. In the past, seed treatments have been beneficial to increasing uniformity and rate of germination, both of which are affected by dormancy. Dormancy has been associated with chemical germination inhibitors in the hull and impermeability of the hull and seed coat to water. During the 1960’s and early 1970’s sodium hypochlorite was used in the soak water, at the rate of one gallon of 5.25% sodium hypochlorite per hundred gallons of water, a 1% solution. The benefit was to alter the chemical germination inhibitors in the hull to improve speed of germination and early growth. Percent germination was not affected. The practice was discontinued when organic seed treatment fungicides were in common use.

**Wet seedbeds and delayed planting.** Late spring rain may make it impossible to adequately dry the seedbed for optimum stand conditions. The result can be lower soil fertility, difficulty in land planing and rolling, precocious weed growth, difficulty in placement of aqua, more algae and delayed planting. If time permits, rework the ground, using a chiselplow, to speed drying. If the ground has not been worked, and there is a stand of vetch or other vegetation, let it grow as long as possible and it will help dry the soil. If the ground is worked wet, expect some of the problems cited above and manage accordingly.

**Drill Seeding.** Drill seeding is used by some to reduce costs and manage herbicide resistant weeds. The primary issues in drill seeding are depth of seed placement and management of moisture for germination. Current rice varieties do not have a high ability to emerge from great depth. Studies in 1985 (Gunnell, et. al) demonstrated a steady reduction in speed of emergence as depth increased in a range of ½ to 3”. Emergence percentage for M-202 was 100%, 100%, 92.5% and 20%, at ½, 1, 2 and 3”, respectively. Deeply planted seeds took much longer to emerge and often came up twisted and bent. There were varietal differences and several varieties (no longer grown) had 100% emergence at all depths. For current varieties, plant no deeper than 1 ½ to 2”. Growers who drill seed can plant to moisture or plant dry and irrigate the field to bring up the seed. The former is better to reduce weeds in the rice, but there is more risk of missing the moisture. Drill seeding into a dry seedbed and flush irrigation reduces risk of stand failure if done properly, but weeds are usually more of a problem.
References


