

Rice Production Manual

Plant establishment

Rationale

Planting the crop on time into a well prepared seedbed will help produce a fast growing, uniform crop that will have higher yields and will be better able to compete with weeds and pests. The best time to plant depends on the locality, variety, water availability and the best harvest time. While rice can be transplanted or direct seeded the yield potential is the same.

Learning objectives

On completion of this section, participants will:

- Be able to identify different rice milling systems
- Have an understanding of the different factors that affect grain quality

Key Activities

During this section participants will:

- Learn the different requirements and techniques for establishing rice
- Have a better understanding of seed quality

Plant establishment

1. Introduction

Planting good quality seed into a well prepared seedbed will help produce a fast growing, uniform crop that will have higher yields and will be better able to compete with weeds and pests. The best time to plant will depend on the locality, variety and water availability. While rice can be transplanted or direct seeded the yield potential is the same. Transplanted crops will mature faster in the production field, however they will take 5-10% longer after establishing the nursery to harvest.



2. Seeding rates and plant populations

The number of plants established will depend on the seedbed, planting technique, depth seeding, seed quality and variety. Many more seeds are sown than actually are established in the field. One kg/ha of seed is equivalent 40,000 seeds or 4 seed /m². When farmers direct seed their crops, only 10-20% of the seeds sown will actually be established. In a nursery, this may increase to 40-50%. The desired number of seedlings established will generally range from 75 to 200 plants per m². Transplanted crops will be at the lower end and dry direct seeded crops at the higher end. To meet the desired planting target in different ecosystems and localities, seeding rates vary between 30kg to 250 kg per ha.

The number of active tillers and panicles produced will be the major determinant of crop yield. Therefore the number of seedlings established must be sufficient to produce the desired number of tillers and panicles. For wet season crops, 300 to 400 panicles per m² are desired; in the dry season this will increase to 500 to 600 panicles per m². Each seedling will develop 3-10 tillers depending on the nutrient status, variety and planting rate and spacing. Higher seeding rates normally give fewer tillers per plant. Transplanted crops generally produce more tillers than direct seeded crops, and dry season crops often produce more tillers than wet season crops.



The number of seedlings transplanted per hill depends on the country, quality of seed, and the price of seed. Three seedlings per hill is normal in most countries. Hybrid seed,

which is more costly, is often transplanted as one seedling per hill while some local varieties are planted using 5 to 6 seedlings in each hill.

3. Seedbed

A well prepared seedbed, in the nursery and production field is necessary to get good germination and establishment. First shoots should start to appear 3-5 days after sowing or irrigation.

For the germination process to begin, the seed must imbibe 10-20% of its own weight. For this to occur quickly, the seedbed must have many soil particles of similar size as the seed to ensure good seed soil contact. In a dry seed bed, seeds absorb water by physical contact with moist soil particles or through "wetting up" after rainfall or irrigation. Seed soaking and seed priming are techniques that expedite the absorption process and will increase the rate of plant establishment.



The depth of planting affects both crop establishment and the potential of the crop to lodge. When dry seeding in heavier clay soils, seeds need to be within 10 to 15 mm of the surface. If seeds are placed at deeper than this, surface sealing may reduce the number of seedlings established and increase the time taken for emergence. When wet seeding, seeds should not sink below the puddled surface. Where possible the water should be allowed to partially clear and soil particles settle before seeding. This may require waiting for up to 48 hours after puddling. High seeding rates and broadcast crops tend to lodge more than transplanted crops.

The following table shows that seeding and water depth greatly influence percent emergence.

Seeding depth (mm)	Water depth (mm)	Germ'n (%)	Seeding depth (mm)	Water depth (mm)	Germ'n (%)	Seeding depth (mm)	Water depth (mm)	Germ'n (%)
0	0	95	13	0	80	25	0	40
0	13	90	13	13	60	25	13	35
0	25	92	13	25	60	25	25	31
0	38	90	13	38	60	25	38	20

Soil Insects. Plant establishment in dry seedbeds may also be reduced by soil borne insect such as nematodes, crickets and wireworms. In most instances, these can be controlled through crop rotation, trap crops, bare fallowing and most importantly flooding. Seed dressing may be used to protect the seed from insects that directly attack the seed but this will not give protection for stem and root feeding insects.

4. Planting Techniques

Crops can be established using dry seed, pre-germinated seed and seedlings. The most suitable planting technique depends on locality, soil type, and crop ecosystem. Crops can be direct seeded by hand broadcast, dibbling, line sowing or drilled using a machine in both wet and dry soil. Transplanted crops can be established manually, either in rows or randomly, or by machine. Direct seeded crops tend to mature faster than transplanted crops but often face more competition from weeds.

Dry broadcast seeding

In many rainfed and deep water ecosystems, dry seed is still manually broadcast onto the soil surface and then incorporated by plowing or harrowing while the soil is still dry. In some deep water or recession rice areas, the seed is not incorporated after broadcasting and germination occurs following rain or rising water levels. This is a very inefficient way to establish a rice crop with a lot of seed lost to birds and rodent and heavy competition from weeds. Seeding rates are normally very high, 150-250kg /ha, and yields are generally quite low at 1-1.5t/ha.



Wet broadcast seeding

In many irrigated and more reliable rainfed areas, pre-germinated seed is broadcast into 2-5cm of standing water. Seeding rates vary from 80-120kg/ha and 1 person can plant 1 ha/day. Standing water levels are normally allowed to recede after seeding and water not added until the seedlings are 1-2 leaf stage. If the soil surface dries too quickly then flash flooding of the fields may be needed. For this system to work effectively, fields must be level and have good drainage system.



Seedling rearrangement will be required within 15-20 days after establishment. Weeds will need to be controlled with 21 days after establishment especially if a pre-emergent herbicide has not been applied. This can be a very effective system for crop establishment, if there is a shortage of labor at planting, weeds can be managed and water controlled.

Broadcasting seedlings

In some irrigation areas especially in China, 12-15day old seedlings are broadcast into standing water. This can be done manually or by machine. The seedlings are established in bubble trays with sand or loam at seeding rate of 30-40kg/ha.



Dibble planting and line seeding

In many upland environments, rice is established using dibbling or line sowing. Dry seeds are placed into a dry seed bed in lines or at set spacing and then covered for protection. Germination occurs after rain and weeds are a major problem. Soil borne insects can also become a major problem and crop rotations may be required to overcome them. Planting rates will vary from 100-200kg/ha.

Drum seeder

Manually operated drum seeders are used for direct seeding in rows. Dry or pre-germinated seed is planted at 80-120kg /ha, in 20-25cm rows. The drum seeder operates best on a seedbed that is level, smooth and with some water standing in the field. Uneven establishment may occur in the row, if the operator varies their walking speed or stops in the field. Some follow up re-arrangement of plants may be required. Drum seeders are manufactured in plastic and metal. Metal versions were found to be best in Africa as rodents attacked the plastic models. The use of drum seeders make it easier for weed control and the use of mechanical weeders.



Dry Machine seeding

In many parts of the world rice is now planted using a seed drill. It is important to match the furrow opener to the soil type and residue levels and also have some means of closing the furrow after the seeding. A smooth, level seedbed is necessary to ensure that seeds are not planted at depths greater than 10 to 15 mm.



"When using a seed drill plant shallow - at the 5-10% of the seed is visible on the surface after sowing"

Seeding rates of 60-80 kg /ha should be sufficient to give the desired plant stand. Most seed drills can plant at 20-25cm row spacing. A good plant stand has 35 to 40 plants established per meter of drill row after permanent water is applied to the field. A benefit of drill seeding is that fertilizer can be applied at the same time as the seed. Both manual and mechanical weeding is much easier in machine-drilled crops than in broadcast crops.



Seed drills have many different types of furrow openers, which are designed for different soil types and crop residues .

Wet machine seeding

There are seed drills available that can plant into wet and puddled soils. The soil surface must be level and the seed bed of even depth. These drills meter and deliver pre-germinated or dry seed, into a groove or furrow which is then covered by a small amount of sand or fine soil. Fertilizer can also be applied at the time of planting. This machine takes advantage of soil puddling but can only be used on tractors which have narrow steel wheels. Water must be added to the field as soon as possible after seeding.



Transplanting

Manual transplanting of rice seedlings into puddled fields is still widely practiced. Transplanted crops require less seed, are better able to compete against weeds but require much more labor to establish. In areas where labor is becoming a problem, mechanical



transplanters are starting to become popular. The total crop duration for transplanted crops will be 5-10% longer than a direct seeded crop, although the actual time in the production field is less.

The soil type often determines how soon the seedlings need to be transplanted after final working. In many sandy soils, transplanting has to be undertaken within hours of final



harrowing before the soil resettles and becomes too hard to manually implant the seedling. In very dispersive soils, transplanting is delayed for two to three days after the final working because the soil is too weak to support the seedling. In areas where there has been insufficient rain, transplanting may also be undertaken in non-flooded soil by using a stick to create the hole to implant the seedling.

Pulling and transplanting of seedlings is very labor intensive. Depending on soil type, one hectare of rice requires 30 to 40 person days to establish. Seedlings are normally hand transplanted 20 -25 cm apart, but this distance may be increased or decreased depending on soil fertility and water supply. The range is normally 15 to 30 cm with 2-3 seedlings placed in each hill.

Mechanical Transplanters

In Asia, a number of different transplanters are now being used to establish rice crops. Machines are manufactured in China, Japan, Korea and Taiwan with varying levels of complexity. Machines range in size from a two-row, walk-behind models to eight-row, ride-on models. Land must be well prepared for machine transplanting. The soil needs to be level and have sufficient bearing strength to carry the machine and support the planted seedlings. Fields may need to be drained one or two days longer than they are for hand transplanting to stop seedlings floating. Most mechanical transplanters place seedlings in rows either 20-30 cm apart with in-row spacing determined by ground speed or head speed of the transplanter.



5. Nurseries

Prior to transplanting, seedlings are grown for varying lengths of time in a nursery. Local varieties are transplanted 30 to 60 days after establishment, while shorter duration improved varieties, should be transplanted within 21 days after establishment.

The type of nursery system used will depend on the variety, the availability of water, labor, land and mechanization. Seedlings can be produced in wet bed, mat or dapog and dry bed methods. For mechanical transplanting seedling boxes are used. There are many different types of nurseries



Wet-Bed Method

The wet bed or traditional nursery, is used in areas where there is sufficient water and land. It is normally in one corner of the production field where water is available. Before broadcasting the seeds, the soil should be thoroughly puddled and leveled and drainage canals made for removal of water. The addition of manure and decomposed compost with a small amount of inorganic N and P fertilizer, will produce strong, vigorous seedlings and make them easier to pull for transplanting. The total seed bed area is normally 10% of the area to be transplanted and requires about 40-50 kg of seed to plant 1 ha of production fields. The best time for transplanting improved varieties is 15-21 days after establishment. Nurseries should be kept free from weeds, pest and disease, and nutrient deficiencies.



Dry-bed method

This type of nursery is prepared dry and beds should be 50-100 cm wide and 5-10 cm high. A layer of semi burnt paddy husk or sawdust can be incorporated in the nursery bed to make pulling of seedlings easier. The area should be free of shade and have adequate irrigation facilities. The total seed bed area needed is about 10% of the area to be transplanted. More seed is required than the wet-bed method as establishment rates will be lower. Planting rates of 80-100kg/ for each production ha are required.



Pulling of the seedlings should be done between 15 - 21 days after establishment and transplanted as soon as possible. The nursery should be kept moist at all times. A basal fertilizer mixture using either organic fertilizers or N and P should be applied and incorporated before sowing.

The advantage of this method is that seedlings are shorter and stronger, with a longer root system than those from the wet bed nursery. The seedlings can be successfully raised during heavy rains, which is not always possible with a wet bed system. Seedling roots may get damaged

during pulling and they may have more problems with blast and pests such as rodents and nematodes.

Mat or Dapog method

Mat nurseries must be grown on a flat surface with a reliable water supply. The area required is 10 m²/ha or 1% of the transplantable area. This is much less than the conventional nurseries. Seeding rates are normally 25-30kg per field ha and the seedlings are best transplanted 12-15 days after establishment.



The soil surface should be covered with banana leaves, poly ethylene sheets or any flexible material prior to planting, to prevent seedling roots penetrating the bottom soil layer. Cement floors can also be used for this purpose. The seed bed should be covered with 1cm burnt paddy husk, compost or sand. Pre-germinated seeds should be spread uniformly on the soil surface to a thickness of 2-3 seeds. Water should be splash onto the seed surface and pressed down by hand or with a wooden flat board. Over watering should be avoided.

The advantage of using a mat system is that the area required and the cost of pulling seedlings is less. As the seedlings are younger, they are subject to less shock during transplanting and are suitable for short duration varieties. However as the seedlings are smaller, transplanting is more difficult. Frequent irrigation should be done to prevent water stress and encourage rapid growth.

Mechanical transplant nurseries

Seedling production for mechanized transplanting is different from hand transplanting. Seedlings are grown on a 1-2cm layer of sand or light soil in trays 30 cm x 60 cm. Like mat nurseries, seeds are spread evenly over the soil surface to a depth of 2-3 seeds and then a fine layer of soil sprinkled over the seed. In some instances, seedlings are grown on larger areas and then cut into rectangular strips or mats that fit the planting trays. Seed rates range from 25-30kg/ha and seedlings are normally planted 10-15 days after establishment. Young seedlings do not suffer the same degree of transplant shock as traditional nurseries



6. Germination Test

A germination test is often the only test a farmer can conduct on his seed before planting. Monitoring the time taken to germinate will also give an indication of vigor. This procedure is very easy, inexpensive and portable.

Sampling

To obtain a random sample for testing it is always best to take samples from different parts of the bag or container. If the grain to be tested is from a seed lot that contains more than one bag, samples must be taken from several bags. **A good rule of thumb for determining how many bags to sample is to sample the number of bags that represents the square root of the lot size.** For example if the lot contains nine bags, then sample at least three bags. If the lot contains 100 bags, then sample at least 10 bags.

Equipment

To conduct this test you will need the following:

- Waterproof tray. A flat-sided water bottle, cut in half lengthwise, makes a good tray.
- Water absorbent material. Tissues or cotton wool are ideal.
- 100 undamaged seeds.
- Water supply.

Procedure

1. Place water absorbent material inside waterproof tray.
2. Take random sample from each seed lot and mix in a container.
3. Take at least three seed samples from the mixed grain.
4. Count out 100 seeds from each sample and place on absorbent paper inside the tray.
5. Carefully saturate absorbent material.
6. Each day check that absorbent materials remain moist and record number of germinated seeds. Do this for 10 days.
7. Compute germination test for five days and ten days
8. Rate of germination is an indicator of vigor. Rapid seed germination increases the chance that seed will establish in the field.

Calculating germination rate

Germination rate is the average number of seeds that germinate over the five-day and 10-day time period.

Germination (%) = Number seeds germinated / Number seeds on tray x100

Example If 86 seeds germinated in a tray of 100 seeds

Germination (%) = $86 \times 100/100 = 86 \%$

“Good quality seed should have a 85- 90% germination in 10days”

7. Plant Establishment Test

The number of plants established in the field relative to the number sown, is the final analysis of success of the planting operation. When determining desired plant populations, farmers inadvertently make allowances for seed quality, soil conditions, seed application techniques, and pests. The procedure to measure establishment rate is very easy, inexpensive and requires little equipment.

Sampling

Sites within the field must be selected at random and be representative of the whole field. This can be done by

- Following a predetermined pattern using transects across the field and sampling at a preset distance along each transect, or
- Randomly throwing a quadrant or marker into different parts of the field.

A transect that is N-shaped or W-shaped and starts at one corner of the field is best. Number of samples taken in each field depends on field size and variability in plant stand. A minimum of ten sites should be sampled in each field; number of sites sampled should be increased for larger fields, especially if large variations in plant numbers are recorded. Avoid selecting sites where plant numbers are known to be either high or low.

Equipment

To conduct this test you will need the following:

- A quadrant- minimum size 50 cm x 50 cm, but 1 m x 1 m is preferred.
- Recording material- pencil is preferred to ink pen.

Procedure

1. Determine sampling techniques. Either transect or throwing quadrant or marker.
2. Place quadrant at selected site. When using distance measurements it is best to place the quadrant corner in line with some part of your foot. The same positioning should be used each time.
3. Count and record the number of seedlings. Be careful not to count tillers or other grass species.
4. Add up the number of plants recorded for all the quadrants counted in each field and divide by the total quadrant area.

Calculate establishment rate

Establishment rate is the average number of seeds that are established in the field after planting and can be expressed on a per ha, per m² or % basis. As an example if 786 seedling counted in 10 m² = 786,000/ha or 79/m² or approximately 20kg seed/ha
If 80 kg of seed was broadcast then 25% were established.

“4 seedlings per m² are equal to approx. 1 kg seed /ha established.”

8. Calibration of Seeding Rates

Hand broadcasting

Establishment of the correct plant population evenly distributed in the field or nursery is critical to minimize cost of planting and to maximize crop yields. To attain this, farmers must convert a planting rate in kg per ha to an equivalent weight of seed for a given area and then apply that seed evenly across the field.

Procedure

To help broadcast the seed evenly, markers should be placed at either end of the field to guide the applicator. Maximum width of throw or distance between markers should be no greater than 5 m. 3 markers tied together with 2 sections of 5 m of string make it a one person job.

To determine weight of seed required per sector,

- Measure width and length of area to be sown in each pass.
- Calculate area as a decimal of one hectare.
- Multiply desired planting rate per hectare by area

Example

Dimensions = 100 m long, 5 m wide

Planting rate = 80 kg per ha

Therefore,

Area = $10000/100/5$ ha or 0.2 ha

Seed required/pass = planting rate (kg per ha) x area (ha)

= 80×0.2 or 16 kg per section (500 m²)

“Field markers are essential when broadcasting seeds”

Calibrating a seed drill

Establishment of the correct plant population is critical to minimize cost of planting and to maximize crop yields. To attain these goals, farmers must be able to calibrate a planting machine. Farmers can use many techniques. The basic outcome is the weight of seed collected for a given area.

Procedure

1. Determine required planting rate and set machine settings on that rate.
2. Measure width of machine (W).
3. Determine distance traveled for 50 revolutions of metering drive wheel of the seeder. This is best done on the surface to be planted by driving the planter across the seedbed for 50 revolutions of metering drive wheel and then measuring distance covered (D).
4. Place seed in seed bin.
5. Either in static position with drive wheel above the ground turn drive wheel 50 turns and collect seed from at least five outlets, or drive planter across seedbed for 50 revs of meter wheel and collect seed from at least five outlets (T)
6. Weigh seed in grams (A).
7. Calculate seeding rate.

$$\text{Seeding rate (S) (kg per ha)} = A \times T \times 10,000 / (N \times D \times W)$$

Where

S = Seeding rate

A = seed from five tubes

T = total no of tubes on machine

N = no of collection tubes

D = distance in 50 revs meter drive wheel

W = width machine

Example

- 1500 gm seed was collected from five seed tubes
- 20 seed tubes on machine
- 50 revs of meter wheel measured 25 meters in distance
- Machine is four meters wide.

Therefore,

$$\begin{aligned} \text{Seeding rate (S) (kg per ha)} &= 1500 \times 5 \times 10 / (50 \times 25 \times 4) \\ &= 15 \text{kg /ha} \end{aligned}$$

“Check the seeding rate before you using a seed drill”

9. Pre-germinating seed

Pre-germinating the seed increases the rate and percentage of seedlings established. Pre-germinating, or soaking of seeds, reduces the time required for seeds to uptake sufficient moisture to initiate the germination process. Seeds are normally pre-germinated for direct seeding into wet puddled seedbeds or standing water.



Procedure

1. Submerge the bag of seed in water for 24 hours or until small shoots appear at end of seed. In some cases this may take 36 hours.
2. Dry the seed in bag for 24 hours.
3. When drying seed make sure it is kept in the shade and air is allowed to circulate around bags. If bag temperatures exceed 42 degrees Celsius, then some seed will be damaged.
4. Broadcast the seed before roots exceed 5 mm in length.
5. When calculating the planting rate, make allowance for expansion in seed volume. Depending on variety, the seed may increase by 10 to 30 percent of its original weight.

“Allow for 10-15% increase in weight when using pre germinated seed”