Plant Establishment

Table Of Contents

TABLE OF CONTENTS 1

INTRODUCTION TO PLANT ESTABLISHMENT 2

SEED QUALITY 2

ENVIRONMENTAL CONDITIONS THAT AFFECT SEED ESTABLISHMENT ... 4

DIRECT SEEDING 6

TRANSPLANTING 7

PLANTING MACHINES 9

SEEDING RATES AND PLANT POPULATIONS 11

GERMINATION TEST 12

PLANT ESTABLISHMENT TEST 13

CALIBRATING SEEDING RATE - HAND BROADCASTING 14

CALIBRATING A DIRECT SEEDER 15

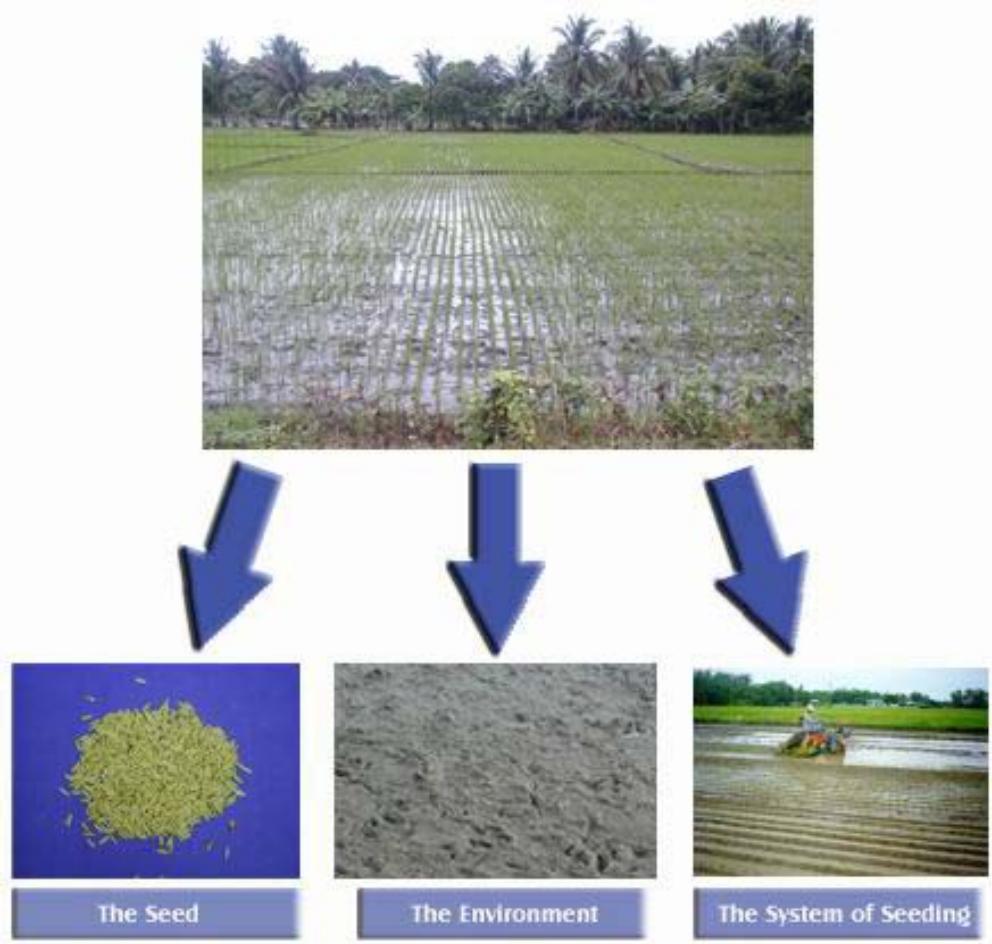
PRE-GERMINATING SEED 16

FIELD EXERCISE 1. PLANT ESTABLISHMENT STUDIES 16

FIELD EXERCISE 2. PLANTING EQUIPMENT 17

Introduction to plant establishment

Rate of plant establishment is affected by three factors: quality of seed, environment in which seed is placed, and manner in which seed is metered and delivered. Number of plants established and seedling vigor will affect competitiveness of the crop against weeds, and ultimately determine final yield potential.



Seed quality

Seed quality is the summation of all attributes that contribute to seed performance. Seeds of high quality are true to variety, and have high percentages for vigor and germination. The main criteria for describing seed quality include purity, percentage of seeds that germinate, and vigor with which they germinate.

Purity refers to genetic or varietal purity. It is also a measure of the degree to which seed is free of seeds from weeds (other crops or species) and inert material (stones, dirt, or twigs). Purity is expressed on a percentage basis by weight.

With impurities Without impurities

Germination percentage expresses the proportion of the total number of seeds that are alive. It is determined through controlled tests and actual counts of the number of seeds that germinate.

Seed vigor is an important factor that may explain the causes of poor seedling establishment. Seeds low in vigor generally produce weak seedlings that are susceptible to environmental stresses. Seeds high in vigor generally provide for early and uniform stands that give seedlings a competitive advantage against environmental stresses.

The seedling

Seed size and plumpness and/or fullness indicate that the seed has potential to produce vigorous seedlings under favorable conditions.

Seed health. High quality seeds should be free from seed borne disease, weed seeds, and other extraneous matter. They should also be free from various types of mechanical injury that reduce germination and seedling vigor.

Quality seeds

Environmental conditions that affect seed establishment

To start growing, a seedling

- absorbs moisture from its surrounding environment
- establishes a root system in a moist layer of soil
- has its shoots and leaves break out above the soil surface.

Several environmental conditions affect a seedling's capacity to do this:

- contact between the seed and soil water
- depth at which seed is placed
- number of pests present.

Seed soil contact

To begin the germination process, the seed absorbs a certain amount of moisture from its surroundings. In a dry seed bed, absorption occurs after distribution through the seed being in contact with moist soil or being submerged in water. For seeds to make good contact with the soil, soil peds (clods) need to be similar in size to the seed and actually make physical contact with the seed. Seed soaking or seed priming prior to planting expedites the absorption process and is often used to increase the rate of plant establishment.

Soil size

Seed placement

Rice seeds must be placed close to the soil surface. When dry seeding into heavier clay soils, place seeds within 10 to 15 mm of the surface. If seeds are placed at depths greater than this, surface sealing will restrict the number of shoots that emerge and increase the time to emergence. When wet seeding, seeds should not sink below the puddled surface. Where possible the water is allowed to partially clear before seeding. This may require waiting for up to 48 hours after puddling.

Soil insects and disease

Plant establishment can be slowed down by the following soil borne insects: nematodes, crickets and wireworms. Some of these problems are alleviated by cultural controls: crop rotation, trap crops, and bare fallowing. Seed dressing protects the seed from insects that directly attack the seed. For stem and root protection, it is necessary to use the appropriate pesticide through surface application or soil fumigation.

Planting Techniques

The most suitable planting technique depends on locality, soil type, and crop ecosystem. Crops can be direct seeded or transplanted. Similarly transplanted crops can be established manually or by machine. Direct seeded crops tend to mature faster than transplanted crops but have more competition from weeds.

Direct Seeded Crop

Transplanted Crop

Direct seeding

Direct seeded crops can be established using dry seed or pre-germinated seed and seedlings. They are broadcast by hand or planted by machine.

Dry seeding

In rainfed and deepwater ecosystems, dry seed is manually broadcast onto the soil surface and then incorporated either by ploughing or by harrowing while the soil is still dry. Care is taken not to incorporate the seed too deeply into clay soils or where surface sealing is a problem.

In some deepwater rice areas, the seed is not incorporated after broadcasting. Germination occurs following rain or floods. To achieve an acceptable level of establishment, the farmer allows for the following factors: seed quality, soil tilth, amount of seed incorporation, and expected availability of water.

The target number of plants to be established ranges from 100 to 150 plants per m2. To meet this target, seeding rates vary between 80 and 250 kg per ha. Some plant rearrangement (transplanting) is normally undertaken within the field after establishment, to even up plant stands. Broadcasting is a very efficient way of reducing labor requirements; normally one or two people can plant one hectare per day.

Pre-germinated seed and seedlings

In irrigated areas, seed is normally pre-germinated prior to broadcasting. Seedlings can be broadcast onto recently drained, well-puddled seedbeds or into pre-standing water in the fields. If

water in the fields is muddy following the last working, the field is allowed to dry for a time period of at least 24 hrs (preferably 48 hrs) before broadcasting commences. If water is drained from the fields after broadcasting, it is re-introduced 10 to 15 days after establishment. In some irrigation areas, seedlings are broadcast post-germination with seedlings 100 to 300 mm in length.

Direct Seeding

Transplanting

Transplanting of rice seedlings into puddled fields is widely practiced in Asia, primarily as a means of weed control. Transplanting requires less seed but much more labor, and the crop takes longer to mature due to transplanting shock.

Seedling nurseries use 15 to 20 percent of the total farming area. In preparing the nursery seedbed, make sure the surface is level, free of weeds, and well drained. Some form of nitrogen and phosphate fertilizer is applied to the nursery. Seeds are pre-germinated and can be broadcast into either a flooded or wet soil surface in the nursery. Seeding rates vary from 500 to 800 kg per nursery hectare depending on locality, soil type, and seed quality

While the majority of rice fields in Asia are manually transplanted, China, Japan, and South Korea also use mechanical transplanters.

Prior to transplanting, seedlings are grown for varying lengths of time in the nursery. Local varieties are transplanted 40 to 80 days after establishment; improved varieties are transplanted within 20 days after establishment. Machine transplanted seedlings are transplanted 15 days after establishment

Seedlings are normally hand transplanted 20 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. Most mechanical transplanters place seedlings in rows 30 cm apart with in-row spacing determined by forward speed.

Hand transplanted

Machine transplanted

In some sandy soils, transplanting is undertaken within hours of final harrowing else the soil becomes too hard to manually implant 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. In some localities, transplanting is delayed for two to three days after the final working because the soil is too weak to support 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 for Hand Transplanting

Hand Transplanting

Seedlings for Machine Transplanter

Mechanical Transplanter

Planting machines

Many different types of planters are used to direct seed rice.

Dry seeder

In Australia and the United States, seed is often placed by a seeder into both dry and moist soil and then irrigated. In Asia, mechanical planting of dry seed is seldom practised. In other countries, rice seed is planted into well-prepared seedbeds using traditional seed drills.

Seed Drill

Seed drills have many different types of furrow openers, which are designed for different soil types and crop residues (Table 1). A smooth, level seedbed is necessary to ensure that seeds are not planted at depths greater than 10 to 15 mm. Covering harrows are drawn behind the combine. Sowing is at the correct depth is when five to ten percent of the seed is visible on the surface after sowing.

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. Manual weeding is much easier in machine-drilled crops than in broadcast crops.

Furrow opener	**Remarks**
Rotating	
Double disk	Suitable for high residue conditions.
Single disk	Better penetration in hard soils but wider variation in seed placement.
Fixed-type	
Chisel	Narrow furrow. Good for deep sowing and in friable soils.
Hoe	Good for stony, harder soil conditions and for deep placement.
Inverted ‘T’	Use for reduced till in free flowing soils. Can leave open furrow in wet soils.
Runner	For shallow depths in loamy non-smearing soils.

Shoe	For placing seed and fertilizer in separate bands.
Shovel	Deep placement causing much soil disturbance.

Table 1. Suitability of furrow openers in different working conditions

Drum seeder

The manually operated drum seeder is used for some wet seeding in eastern Asia. The drum seeder operates best on a seedbed that is very level, smooth and wet. The drum seeder is very heavy to pull and can leave gaps and multiple seedlings in the planted row. Uneven seeding occurs: many seeds are dropped when the operator stops, and then no seeds are dropped until the seeder has moved forward for a small distance. Uneven seeding leads to a very uneven plant stand and follow up transplanting may be required.

Drum Seeder

Transplanter

In Asia, a number of different transplanters are successfully used to establish rice. 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.

For seedling production, mechanized transplanting requires techniques that are different from hand transplanting. Seedlings are often grown on a thin layer of soil in 30 cm x 60 cm trays. In some instances, seedlings are grown on larger areas and then cut into rectangular strips (mats of seedlings) that fit into the planting trays of the transplanter. Seedlings can be planted out 10 to

15 days after establishment.

Seeds sown on trays

Seedlings

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.

Seeding rates and plant populations

Seeding rate and desired plant population depend on several factors: the rice ecosystem, planting technique, planting depth, seed quality and seed variety.

Total number of panicles required per unit area can vary, depending on soil type and water regime. For most situations, tillers and panicles are thought of as similar although not all tillers produce panicles. For wet season crops, 300 to 400 panicles per m2 are desired; in the dry season density increases to 500 to 600 panicles per m2. In more fertile soils and for irrigated and dry season crops, plant populations should be increased.

Rice Panicles

Each plant develops three to seven tillers. The number of tillers will vary according to nutrient

status, variety and planting rate (higher seeding rates normally give fewer tillers). Transplanted crops generally produce more tillers than direct seeded crops, and dry season crops often produce more tillers than wet season crops.

Plant establishment rates for broadcast crops are less than for transplanted crops. When planted in nurseries, 60 percent of the seeds will establish. This will reduce to 50 percent when broadcast directly into the fields. Planting rate ranges from 80 to 250 kg ha-1 for broadcast crops and 500 to 800 kg per nursery hectare for transplanted crops.

Number of seedlings transplanted per hill depends on three factors: country, quality of seed, and price of seed. Hybrid seed, which is more costly, is often transplanted as one seedling per hill while some local varieties are planted with 5 to 6 seedlings in each hill. Most countries plant two to three seedlings per hill.

One plant per hill

5 to 6 plants per hill

Depth of planting affects both crop establishment and lodging potential. Broadcast crops tend to lodge more because with the seed germinating at the surface, the crown of the plant is at or above ground level. Care must be taken with seed placement as rice seeds have difficulty establishing if placed too deep in the soil. 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

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 take samples from a 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.
- One hundred 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.

$$\text{Germination (\%)} = \frac{\text{Number seeds germinated}}{\text{Number seeds on tray}} \times 100$$

Example

If 86 seeds germinated in a tray of 100 seeds

$$\text{Germination (\%)} = \frac{86}{100} \times 100 = 86\ \%$$

Plant establishment test

The number of plants established in the field relative to 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.

$$\text{Establishment rate} = \frac{\text{Number plants}}{\text{Area } (m^2)}$$

Example

786 seeds established per 2.5 m2

$$\text{Establishment rate} = \frac{786}{2.5} = 314 \text{ per } m^2$$

This can be expressed as an establishment percentage if the 1000 seed weight and the planting rate in kg per ha are known. Depending on variety, each kilogram of seed will contain between 40 to 50,000 seeds. Therefore each 100 seedlings established per square meter represents 2.0 to 2.5 kg of seed per ha.

In the above example, 314 seedlings per m2 represent 7 kg per ha of seed.

Calibrating seeding rate - Hand broadcasting

Establishment of the correct plant population which is evenly distributed in the field or nursery, is critical to minimize cost of planting and to maximize crop yields. To attain these goals, 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 five meters.

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

Therefore,

Dimensions	= 100 m long, 5 m wide
Planting rate	= 80 kg per ha

Therefore,

Area	= 10000/100/5 ha
	= 0.2 ha

Seed required	= planting rate (kg per ha) x area (ha)
	= 80 x 0.2
	= 16 kg per section (500 m^2)

Calibrating a direct seeder

Establishment of the correct plant population is critical to minimize cost of planting and to maximize crop yields. To attain these goals, farmers must calibrate a planting machine. Farmers can use many techniques. The basic requirement 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.

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

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,

$$\text{Seeding rate (S) (kg per ha)} = \frac{1500 \times 5 \times 10}{50 \times 25 \times 4} = 15 \text{ kg per ha}$$

Pre-germinating seed

Pre-germinating the seed increases 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 when directly sown 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 or sterilized.
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.

Field Exercise 1. Plant establishment studies

There are many different ways to establish rice crops. The method selected will depend on soil type, type of land preparation, water availability, time of year and local customs. This exercise is designed to study rice plant establishment from seed germination potential to plant establishment in the field. It does not involve transplanting although transplanted crops are established in nurseries using any one of these techniques.

Necessary techniques include the following: germination test, plant establishment test, seed cleaning, and calibration.

Planting systems that will be compared are as follows:

- Dry seeding (broadcast) and then irrigating
- Dry seeding (broadcast) into water
- Primed seed (overnight soaking)
- Pre-germinated seed onto wet surface (nursery establishment)
- Pre-germinated seed into standing water
- Machine-seeded and irrigated (demonstrated in exercise for whole group)

Requirements to complete this exercise are as follows:

1. Grade the seeds.
2. Undertake germination test.
3. Determine seed required to plant plots at 100 kg per ha equivalent.
4. Pre-germinate the required amount of seed.
5. Measure plots and determine amount of seed to be broadcast into each plot.

6. Broadcast seed into plots and irrigate where necessary.
7. Monitor rate of establishment.

Outcomes

1. Calculate number of seeds in one kg of seed.
2. Calculate percent of light seeds in the bag sample.
3. Calculate change in weight by pre-germinating seed for 24 hrs.
4. Plot rate of establishment for each technique for four days, six days, and eight days.
5. Determine most appropriate technique or system for your environment.

Field Exercise 2. Planting equipment

1. Observe different planters and systems. Note the seed metering system, delivery tubes, furrow openers, and furrow closers.
2. Discuss advantages and disadvantages of using different planting equipment. Note suitability for different seeds, application of fertilizer, soil conditions, and weeding ability.

Index

1

10-day 12

2

24
bag 16
water 16

5

50
reduce 11
traveled 15
500
increases 11

A

Affect 4
seedling's 4
Affect seed establishment 4
And/or 2
Asia 7, 9
Australia 9

B

Bag 16
24 16

C

Calibrating 15
direct seeder 15
Celsius 16
China 7, 9
Closers 17
Competitiveness 2

D

D 15
Deepwater 6
Direct 6
Direct Seeded Crop **Transplanted Crop** 4
Direct seeder 15
Calibrating 15
Direct Seeding 6
Drum Seeder 9

E

Environmental conditions 4

F

Field Exercise 16, 17

G

Germination test 12
Germ'n 11

H

Ha-1 11
Hand 14
Hand Transplanting **Hand Transplanting** 7
Hrs 6, 16

I

Increases 11
  500 11
Introduction 2
  plant establishment 2
Inverted 'T' 9

J

Japan 7, 9

K

Korea 9

M

M 13, 14
M2 ..... 6, 11, 13, 14
Machine 7, 9
  Planting 9
Machine Transplanter **Mechanical Transplanter** 7
Machine-drilled 9

N

N 15
N-shaped 13

P

Peds 4
Pesticide Application 4
Plant establishment 2
  Introduction 2
Plant establishment test 13
Plant populations 11
Planting 4, 9
  machines 9
  Techniques 4
Post-germination 6
Pre-germinating 16
  seed 16

R

Rainfed 6
Rates 11, 14
  Seeding 11

Reduce 11
50 11
Rice Panicles 11

S

S 15
Seed Drill 9
Seed quality 2
Seeding 11, 16
Pre-germinating 16
rates 11
Seedling's 4
affect 4
Seedlings 9
South Korea 7

T

T 15
T x10
000 15
Taiwan 9
Techniques 4
Planting 4
Traveled 15
50 15

U

United States 9

W

W15
Water 16
24 16
Wireworms 4
W-shaped 13