Step-by-step production

Pre-planting

Pre-planting activities involve choosing the right variety, developing a cropping calendar, and preparing the rice field for planting.

Postproduction

After harvesting, the rice paddy undergoes postharvest processes including drying, storage, and milling to ensure good eating quality and marketability.

Growth

Important management factors should be considered during the growth of the rice crop. These include planting method, water, fertilizer, weeds, and pests and diseases.

Pre-planting

How to select rice varieties

Use healthy seeds of a locally adapted variety to get a good crop that has high yield potential and a good market price.

How to develop a crop calendar

Use a crop calendar to better plan all farm activities and the costs of production.

How to ensure seed quality

Seed is the foundation of any rice crop. It must be grown, harvested, and processed correctly for best yield and quality results.

How to prepare the rice field for planting

A well-prepared land controls weeds, recycles plant nutrients, and provides a soft soil mass for transplanting and a suitable soil surface for direct seeding.

How to select rice varieties

Use healthy seeds of a locally adapted variety to get a good crop that has high yield potential and a good market price.Each rice growing country should have a list of released varieties within the country.IRRI provides small quantities of seeds on demand to any individual or organization anywhere in the world for the purposes of research, breeding, or training for food and agriculture.

Characteristics

Rice varieties should have

- Good grain quality (especially cooking characteristics, color, shape, taste and aroma, and head rice recovery)
- High market price
- Optimum yield potential and stability over seasons
- Maximum tillering capacity for weed competition
- Resistance or tolerance to major diseases, insects, and other stresses (i.e. drought and flood) of the area
- The right growth duration (maturity length) to match the season
    - Avoid varieties that need to be planted or harvested earlier or later than surrounding rice fields to minimize pest damage (e.g., birds during maturation), and growth problems during times of harmful environmental conditions (e.g., late-maturing varieties running out of water)
- Resistance to lodging under normal farmer management

Factors affecting crop management, such as soil type, planting method (e.g. some varieties are better for direct seeding), fertilizer efficiency, amount of rainfall, climate, disease pressure, should also be considered in selecting varieties.

Climate change-ready rice

Drought-tolerant rice varieties

Drought is the most widespread and damaging of all environmental stresses, affecting 23 million hectares of rainfed rice in South and Southeast Asia.

IRRI has developed drought-tolerant varieties, which have been released in several countries and are now being planted by farmers. These include *Sahbhagi dhan* in India, *Sahod ulan* in the Philippines, and the *Sookha dhan* varieties in Nepal. Field trials suggest that the average yield advantage of drought-tolerant varieties over drought-susceptible ones is 0.8–1.2 tons per hectare under drought conditions.

Submergence-tolerant rice varieties

Rice plants normally die within four days of submergence. Farmers in countries with rice areas prone to flooding—such as the Philippines, Bangladesh, and India—lose millions tons of rice yearly due to floods.

IRRI discovered *SUB1*, the gene for flood tolerance, and incorporated this gene into popular rice varieties. Field trials of rice varieties with the *SUB1* gene have shown a yield advantage of 1–3 tons per hectare, following flooding of 10–15 days. Flood-tolerant varieties have been released and are now being planted across Asia. These include IR64-Sub1 in the Philippines, *Swarna-Sub1* in India, *Samba Mahsuri-Sub1* in Bangladesh, and *Ciherang-Sub1* in Indonesia.

Salt-tolerant rice varieties

Millions of hectares of land in Asia and Africa suitable for rice production are currently unproductive because of high or increasing salt content in soil. Rising sea levels bring saltwater further inland, contributing to soil salinity. Rice productivity in salt-affected areas is very low—less than 1.5 tons per hectare.

A gene for salinity tolerance, called *Saltol*, has been incorporated into popular rice varieties in countries across Asia. In the Philippines, field trials of *Salinas* suggest a yield advantage of at least 2 tons per hectare over non-tolerant varieties.

How to ensure seed quality

Good quality seeds (left) are uniform in size, full, and plump; while poor quality seeds (right) are often discolored.

Seed is the foundation of any rice crop. It must be grown, harvested, and processed correctly for best yield and quality results.

Sowing good quality seeds leads to lower seed rate, better emergence (>70%), more uniformity, less replanting, and vigorous early growth which helps to increase resistance to insects and diseases, and decrease weeds. As a result, yield can increase by 5−20%.

While different countries have different standards for seed quality the following factors are used to classify rice seeds:

Varietal purity

Good seed is pure, from a single variety.

Varietal purity tests include looking for percentage of (1) germination, (2) other mixed in varieties, (3) weed seeds and other crop seeds, (4) inert material (stones, soil, etc.), (5) red rice seeds, and (6) moisture content.

Seed lot purity

Impurities refer to the degree of contamination caused by (1) weed seeds, (2) seeds of other crops or species, and (3) inert material such as stones, dirt, or twigs. It is expressed as a percentage, by weight.

To measure seed lot purity:

1. Randomly select a seed sample. 100 g is a good sample size.
2. Weigh the sample. **[A]**
3. Remove all of the weed and other crop seeds.
4. Weigh the removed weed and other crop seed matter. **[B]**
5. Compute the weed percentage using the following formula:

$$\% \text{ Weed} = \frac{\text{Wt. of weed [B]}}{\text{Total Wt. of sample [A]}} \times 100$$

6. Weigh the inert matter removed from the sample **[C]**, the inert matter percentage is calculated using the formula:

$$\% \text{ Inert matter} = \frac{\text{Wt. of Inert matter [C]}}{\text{Total Wt. of sample [A]}} \times 100$$

Germination percentage

Germination percentage expresses the proportion of the total number of seeds that are alive. Good seeds have more than 80% germination rate.

Many varieties have a dormancy period immediately after harvest. When stored under traditional open systems, the germination rate of most rice seed begins to deteriorate rapidly after 6 months.

To test seed germination:

1. Select a number of small random samples from the seed to be planted and select a subset (e.g., 200 seeds) of the combined sample. Soak the seed in water for 24 hours.
2. Arrange 100 soaked seeds in a grid pattern on a wet paper towel.
    - Place the paper in a closed container or
    - Cover the seeds with another moist paper towel and roll together and place the sample in a plastic bag
3. Ensure paper remains moist (but not wet to the point of water running off – or seed will rot).
4. Count the germinated seeds 3 and 5 days later and record how many have germinated.

5. Compute the germination percentage using the following formula:

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

At least 80 seeds should have germinated to be considered "good seed" (80% germination).

Fact sheet: How to conduct germination test

Seed establishment vs germination

It is best to also check seed germination in soil, as emergence can often be 70% or less of germination.

To test, place 2 samples of 100 seeds in a tray filled with soil. Cover lightly with soil (e.g., 5 mm), keep moist and count establishment after 7 days.

Note: Larger seeds tend to establish better then smaller seeds.

Discoloration

Fungi, bacteria, and environmental conditions such as high humidity and temperature (i.e. 27−35°) cause discoloration.

Other rice diseases do not produce consistent discoloration. Any seed having more than 0.5% differently colored or spotted seed surface is considered discolored. Discoloration can occur on fully or partially filled or empty grains.

There are two types of discoloration on rice seeds:

1. Spotting, which is caused by certain diseases (brown spot) or insects (rice bug feeding damage)
2. Discoloration on a portion or portions of rice seeds can be caused by black kernel fungus, stackburn disease, or sheath rot on certain occasions.

Red Rice kernels are not acceptable in the rice market place. Kernels should not have more than 25% of its surface area colored red or red streaked.

Seed size, plumpness, and/or fullness are generally desirable seed characteristics. These indicate that the seed can potentially produce vigorous seedlings under favorable conditions.

Fact Sheet: How to measure varietal purity

Read: IRRI Rice Quality Assessment Kit

Seed viability

The viability of seed in the field is determined by its germination potential, vigor, and moisture level.

The rate of germination is an indicator of vigor.

Rapid seed germination increases the chance that seed will establish well in the field.

Fact sheet: How to conduct germination test

Seed vigor refers to the seed's level of activity and performance during germination and seedling emergence. The ability of the germinating seed to continue to grow and survive is important in crop establishment.

Seeds that are low in vigor generally produce weak seedlings that are susceptible to environmental stresses. On the other hand, seeds that are high in vigor produce early and uniform stand, which gives them a competitive advantage against environmental stresses.

Moisture content

Moisture content is the amount of water in the rice grain.

It influences the life and vigor of the seed. The amount of moisture should be less than 14%, and preferably less than 12% for extended storage times.

Read: How to measure the moisture content

Read: Grain moisture content and quality in postharvest

How to obtain good seed

- Buy certified seed that is pure and labeled
- Get farmer-produced good seed, or
- Select your own good seed

High quality seeds are free from weed seeds, seed-borne diseases, insects, pathogens, and other extraneous matter. They should also be free from various types of mechanical injury that reduce germination and seedling vigor.

In case of infected or low quality seeds, treatments can be done.

How to develop a crop calendar

Using a crop calendar allows better planning of all farm activities and the cost of production.

A cropping calendar is a schedule of the rice growing season from the fallow period and land preparation, to crop establishment and maintenance, to harvest and storage.

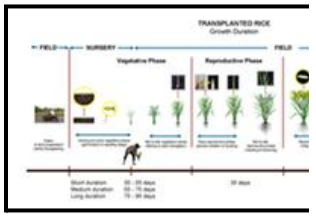
The crop calendar allows a farmer to:

- plan for input purchase and use
- develop cash flow budget for year
- determine need credit and period requirement
- determine labor requirements and plan for peak usage times
- organize contractors for land preparation and harvesting

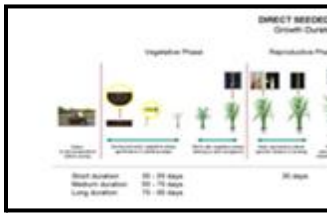
1. Determine the best date to plant. This information can be gathered from local experience, agricultural advisors and leading farmers in the district.

2. Determine the time the variety takes from planting to harvest. The length of time from establishment to harvest is known for each variety. It may vary a little depending on the growing conditions especially water availability and solar radiation. Normally short duration varieties take 100−120 days, medium duration 120−140 days, and long duration 160 days plus.

Growth duration diagrams



Transplanted rice



Direct seeded rice

3. Most varieties take 60−65 days from panicle initiation to harvest.
4. Mark on the calendar the date of planting and then when each other operation needs to be done (plowing, weeding, fertilizing, harvesting).
5. Then determine how much labor, equipment and finance will be required at each step during the growing period.
6. Pin the calendar in a prominent place to remind you when things need to be done.

Check our related Micromodules in Openlearning.cgiar.org

How to prepare the rice field for planting

Land preparation is important to ensure that the rice field is ready for planting. A well-prepared field controls weeds, recycles plant nutrients, and provides a soft soil mass for transplanting and a suitable soil surface for direct seeding.

Land preparation covers a wide range of practices from zero-tillage or minimum tillage which minimizes soil disturbance through to a

totally 'puddled' soil which actually destroys soil structure.

It typically involves (1) plowing to "till" or dig-up, mix, and overturn the soil; (2) harrowing to break the soil clods into smaller mass and incorporate plant residue, and (3) leveling the field.

Initial land preparation begins after your last harvest or during fallow period. This is important for effective weed control and for enriching the soil. Generally, it will take 3−4 weeks to prepare the field before planting.

Clear the field

- At dry field condition, apply glyphosate to kill weeds and for better field hygiene.
- Irrigate the field 2−3 days after glyphosate application.
- Maintain standing water at 2−3 cm level for about 3−7 days or until it is soft enough and suitable for an equipment to be used.
- Plow or rotovate the field to incorporate stubbles and hasten decomposition.

Implements: Power tiller with attached moldboard plow, Hydrotiller, Rotovator

- Flood the field. Keep it submerged for at least two weeks. Let the water drain naturally to allow volunteer seeds and weed seeds to germinate.

Depending on weed population and soil condition, another tillage operation can be done.

Create compost from rice residues

Composting converts crop residues into better organic fertilizers. To create a compost:

1. Ensure that the field is level, well drained, and under shade.

2. Chop compost materials into small pieces (3−5 cm).
3. If possible, build compost heaps in layers consisting of rice crop material, combined with legume or manure wastes, on a 2:1 ratio.
4. Keep compost heaps moist—not to wet and not too dry. Make sure that no water drains from the compost pile. If rice straw cracks when bent, then the compost must be too dry.
5. Sprinkle compost heap with decaying material (e.g., cow urine), a dilute solution of N fertilizer such as urea, and/or with a micro-organism solution (e.g., tricho). This will decompose the materials faster.
6. Mix and turn the heaps every two weeks.
7. Compost should be ready within 4−8 weeks if moisture and temperature conditions are good.

Read: Use crop residues as mulches

Plant cover crops

Growing cover crops help suppress weeds and enrich the soil.

Crops that can be planted after harvest include nitrogen fixing crops like *Sesbania, Azolla,* and other legumes such as mung bean and cow pea.

Read: What are cover crops?

Different rice ecosystems have different land preparation requirements. Lowland rice fields, for example, are usually puddled to develop a hard pan and reduce water loss. Upland ricefields, on the other hand, do not necessarily have to be puddled. In resource-limiting environments, dry preparation can be adapted.

Did this page help you?

Wet Preparation

Wet preparation may be appropriate if...

- My farm has access to irrigation.
- My field is surrounded by bunds that enable flooding.
- My farm has a loamy to clay type of soil.
- I have equipment for primary tillage, secondary tillage, and leveling.

Read more

Dry Preparation

Dry preparation may be appropriate if...

- I do not have access to irrigation and water supply is limited.
- I have equipment and machinery available for tillage and/or labor is a limiting factor.
- My farm has a coarse, sandy type of soil.
- My field has a well-established hard pan, I have planted rice on it many times and I can control weeds with methods other than flooding.

Growth

How to plant rice

Rice crops can either be direct seeded or transplanted. In direct seeding, seeds are sown directly in the field. While in transplanting, seedlings are first raised in seedbeds before they are planted in the field.

How to manage soil fertility

Soil fertility is essential for a rice plant to grow and develop normally. A number of crop problems can be related to nutrient imbalance in the field.

How to manage pests and diseases

Farmers lose an estimated average of 37% of their rice crop to pests and diseases every year. Timely and accurate diagnosis can reduce losses.

How to manage water

Rice is extremely sensitive to water shortages. Good management practices are critical to maximize water efficiency and yield.

How to control weeds

Control of weeds during land preparation is crucial to reduce the amount of weed pressure in the field. Loss of yield to weeds is the worst during 0–30/40 days after sowing or transplanting (DAS/DAT).

How to plant rice

 Rice crops can be either direct seeded or transplanted.

In direct seeding, seeds are sown directly in the field. While in transplanting, seedlings are first raised in seedbeds before they are planted in the field.

When choosing the suitable planting method, the (1) locality, (2) type of soil, (3) rice ecosystem, and (4) availability of inputs and labor, should be considered.

Choosing *when* to plant is crucial to establishing the crop in the field. Timely planting into a well prepared seedbed will help produce a fast growing, uniform crop that will have higher yields and better competition against weeds and other pests. The best time to plant depends on locality, variety, weather, water availability, and the best harvest time. Planting at the same time (or within a 2 week window) as the neighboring fields can help to minimize insect, disease, bird, and rat pressure on individual fields.

Direct seeding requires 60−80 kg of seeds per ha, while transplanting only requires 40 kg per ha, at 2 plants per hill.

 Snail management is critical during the first 10 days of transplanted crops, and first 21 days of direct seeded crops.

Golden apple snails eat young and emerging rice plants. They cut the rice stem at the base, destroying the whole plant.

Fact sheet: How to manage golden apple snails

The number of plants established and its seedling vigor will affect the competitiveness of the crop against weeds, and determine the final yield potential.

Did this page help you?

Transplanting

Transplanting may be appropriate if...

- I have a space for nursery.
- I have available resources for seedbed preparation.
- I have equipment for transplanting and/or labor is not a limiting factor.

Read more

Direct seeding

Direct seeding may be appropriate if...

- I have limited resources.
- I want to reduce labor costs.
- I prefer my crops to mature faster.

Read more

How to prepare the seedlings for transplanting

Prior to transplanting, seedlings need to be raised in a nursery. Seedling nurseries usually use 5−10% of the total farming area.

How to manage water

Rice is typically grown in bunded fields that are continuously flooded up to 7−10 days before harvest.

Continuous flooding helps ensure sufficient water and control weeds.

Lowland rice requires a lot of water.

On average, it takes 1,432 liters of water to produce 1 kg of rice in an irrigated lowland production system. Total seasonal water input to rice fields varies from as little as 400 mm in heavy clay soils with shallow groundwater tables to more than 2000 mm in coarse-textured (sandy or loamy) soils with deep groundwater tables.

Around 1300−1500 mm is a typical amount of water needed for irrigated rice in Asia. Irrigated rice receives an estimated 34−43% of the total world's irrigation water, or about 24−30% of the entire world's developed fresh water resources.

Worldwide, water for agriculture is becoming increasingly scarce. Due to its semi-aquatic ancestry, rice is extremely sensitive to water shortages.

To effectively and efficiently use water and maximize rice yields, the following good water management practices can be done:

STEP 1 Construct field channels to control the flow of water to and from your field

STEP 2 Prepare the land to minimize water loss and create a hard pan

-
-
-
-
-
-
-

STEP 3 Level the field

STEP 4 Construct bunds and repair any cracks or holes

Different crop establishment methods require different water management practices:

For continuous flooding
For safe Alternate Wetting and Drying

 Continuous flooding of water generally provides the best growth environment for rice.

After transplanting, water levels should be around 3 cm initially, and gradually increase to 5−10 cm (with increasing plant height) and remain there until the field is drained 7−10 days before harvest.

For direct wet seeded rice, field should be flooded only once the plants are large enough to withstand shallow flooding (3-4 leaf stage).

Lowland rice is extremely sensitive to water shortage (below saturation) at the flowering stage. Drought at flowering results in yield loss from increased spikelet sterility, thus fewer grains.

Keep the water level in the fields at 5 cm at all times from heading to the end of flowering.

In case of water scarcity, apply water-saving technologies such as Alternate Wetting and Drying (AWD) and consider changing planting method from puddled transplanting to non-puddled transplanting or dry-direct seeding.

How to manage soil fertility

Applying nutrients to the crop is essential in managing soil fertility so the plants grow and develop normally. A number of crop problems can be related to inefficient management of nutrients and nutrient imbalances in the field.

Site-Specific Nutrient Management

Site-specific nutrient management (SSNM) enables farmers to dynamically adjust fertilizer use, by supplying optimum amounts of nutrients at critical time points in the crop's growth to produce high yields.

In SSNM, farmers tailor their nutrient management strategy to the specific conditions of their field.

The following are steps in SSNM:

STEP 1 Establish an attainable yield target

Identify estimated yield based on location and season. Consider factors such as climate, rice cultivar, and crop management.

The yield target determines the total amount of nutrients that must be taken up by the crop.

STEP 2 Effectively use existing nutrients

Indigenous nutrients which comes from the soil, along with organic materials, crop residues, manures and irrigation, need to be managed properly to achieve optimal crop nutrient uptake.

Read: Use crop residues as mulches | How to make a compost | What are cover crops

STEP 3 Apply fertilizer to fill in other nutritional needs of the crop

NPK fertilizers are applied to supplement indigenous nutrients.

The quantity of application is determined by the target yield and the amount of nutrients needed by the crop.

To assess the crop's nutrient needs, use the Leaf Color Chart.

Fact sheets: Nitrogen (N) | Phosphorus (P) | Potassium (K) | Zinc (Zn)

Go to web app: Rice Crop Manager

Read: for researchers and scientists - SSNM explained | SSNM in detail

Fact sheets: for farmer-managed research - Addition plots | Nitrogen split applications | Nutrient omission plots

Crop Manager

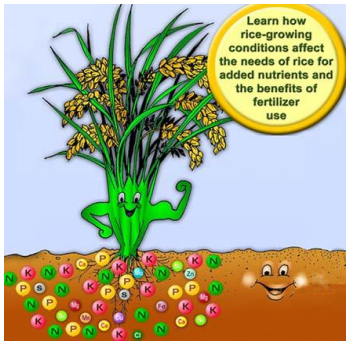
Rice Crop Manager

Rice Crop Manager (RCM) is a computer- and mobile phone-based application that provides extension agents and farmers with advice on crop and nutrient management matching their particular farming conditions.

Location-specific guidelines are currently available in Bangladesh, China, India, Indonesia, the Philippines, and West Africa.

Go to web app: Rice Crop Manager | RCM Tutorial

Nutrient Teacher for Rice



Nutrient Teacher for Rice is a teaching tool on RCM. This app is made for students and instructors of introductory courses in soil science and crop science. It can also be used by researchers.

It shows how information on season, crop establishment, variety, growth duration of rice, yield, residue management, soil fertility, and use of organic materials as sources of nutrients affect rates of nitrogen (N), phosphorus (P), and potassium (K) fertilizer.

How to control weeds

Weed control is important to prevent losses in yield and production costs, and to preserve good grain quality. Specifically, weeds

- decrease yields by direct competition for sunlight, nutrients, and water
- increase production costs e.g., higher labor or input costs
- reduce grain quality and price
  For example, weed seeds in grain can cause the buyer price to be reduced.

Weed management should be practiced during specific stages of rice production:

During land preparation

Control of weeds during land preparation is crucial to reduce the amount of weed pressure in the field. Land preparation should start 3−4 weeks before planting. Plowing destroys weeds and remaining stubble from the previous crop. Weeds should be allowed to grow before the next cultivation. In addition, a level field helps retain a constant water level that controls weeds.

For wet seeded rice

- Plow and harrow several times before planting. Depending on weed population, three or more operations can be done.
- Allow weeds to emerge for at least 2 weeks then kill by another shallow tillage. This reduces the number of weed seeds in the soil, and greatly reduces weeds for the subsequent crop.

For dry seeded rice

- Allow weeds to emerge within 1−2 weeks, then kill them with either a non-selective herbicide or by light cultivation.
- Spray herbicides, and perform manual and/or mechanical weeding.

Read: Establishing rice plant through direct seeding | Stale seedbed technique

Read: Control weeds by using crop residues as mulches

Fact sheets: Chemical weed control | Cultural weed control

In the nursery

To control weeds in the nursery

- Prepare land two weeks before seeding.
- When using soil mix for nursery beds, make sure the soil is clean and free of weed seeds.
- If there are weed seedlings in the nursery bed, separate them from rice seedlings during pulling and bundling to avoid planting weeds.
- Apply pre-emergence herbicide 2−3 DAS.

Read: What are the different nursery systems

Fact sheets: Chemical weed control | Cultural weed control

During early crop growth

Weed control is critical after planting until the canopy closes. Control methods vary depending on the rice ecosystem and planting method:

For transplanted rice

- Apply pre-emergence herbicide (e.g., pretilachlor or butachlor at 2−3 DAT)
- If grass weeds are the main weed problem, apply early post-emergence herbicide

Read: List of herbicides for transplanted rice in the Philippines (pdf)

- Do not allow soil surface to dry after transplanting. Keep the soil moist to saturated. Dry soil reduces the performance of pre-emergence herbicides.
- Maintain a 5−7 cm water depth to prevent germination of weeds until 7−10 days before harvest.
- If herbicides have not been applied, or if weeds are emerging, you may use push weeder to control weed seedlings that are at 3−4 leaf stages. Irrigate one day later to prevent buried and uprooted weeds from recovering.
    - Maintain shallow flooding 7−10 DAT, drain the field, then push the weeder down the row to bury emerged weed seedlings.
    - Leave the field saturated for 2 days to keep the buried weed seedling in the mud layer then flood the field up to 5 cm of water.
- Handweed as needed until the canopy closes.

For wet seeded rice (broadcast or drum seeded)

- Apply pre-emergence herbicide (e.g., pretilachlor + fenclorim 2−3 DAS)
- If grass weeds are the main weed problem, apply early post-emergence herbicide

For post-emergence herbicide application, drain water in the field to expose weeds, then spray the herbicide.

Note: Post-emergence herbicide should come in contact with leaves of weeds to be absorbed by the weeds. When weeds are submerged in water, post-emergence herbicide will not be effective.

Read: List of herbicides for direct seeded rice in the Philippines (pdf)

- Do not allow soil surface to dry after seeding. Flush irrigate as needed to keep the soil moist to saturated. A dried soil surface will reduce the performance of pre-emergence herbicides.

Irrigating more than 10 days after seeding encourages more weed growth and deeper water level is needed to control weeds.

- If herbicides have not been applied, or if weeds are emerging, you may use push weeder in a row-seeded crop to control weed seedlings that are at 3−4 leaf stages. Irrigate one day later to prevent buried and uprooted weeds from recovering.
- Maintain a 5−7 cm water depth to prevent germination of weeds until 7−10 days before harvest.
- Handweed as needed until the canopy closes.

For dry seeded rice

- A weed-free field is essential for early vigor in a dry-seeded rice crop. Be sure to follow steps for weed control during land preparation to avoid yield loss to weeds.

> **Read:** How to prepare the rice field for planting (Dry Preparation) | List of herbicides for direct seeded rice in the Philippines (pdf)

- Apply pre-emergence herbicide (e.g., oxadiazon or pendimethalin) onto a moist soil 2−3 DAS. If the seed is sown on dry soil, flush irrigate the field first then spray the herbicide.

> Pre-emergence herbicides should not be applied in standing water to avoid toxicity.

> **Read:** Knockdown and pre-emergence herbicide in DSR (pdf) from Direct Seeded Rice (DSR) in the Eastern Gangetic Plains of India

- Handweed as needed until the canopy closes.

Fact sheets: Manual weed control | Mechanical weed control | Chemical weed control

Go to web app: Weed Identification tool

Did this page help you?

Stale seedbed technique

Stale seedbed technique is a weed control method for land preparation. This technique is effective especially when growing irrigated, dry direct seeded rice.

Read more

Herbicides

Using herbicides for weed control is particularly important in places where agricultural labor is scarce and wage rates are high.

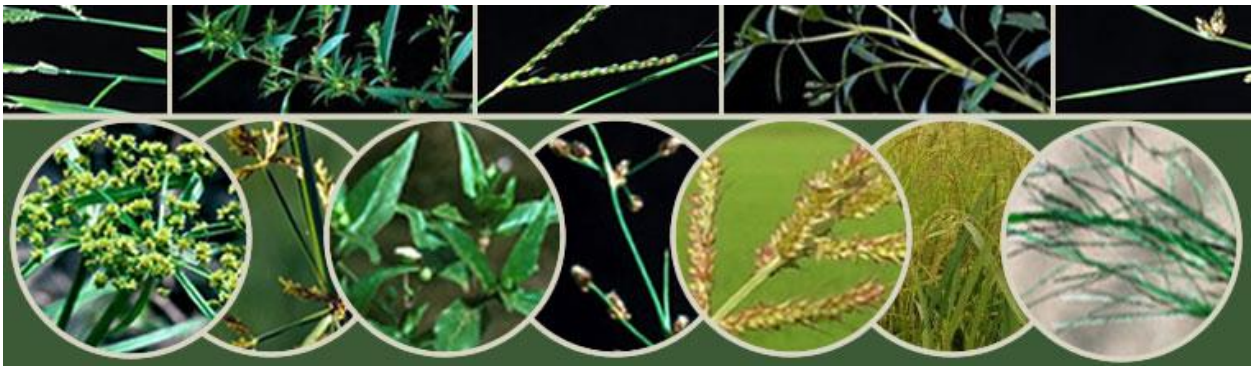
Read more

Manual and mechanical weeding

Direct control of weeds can be done through manual weeding by hand, and mechanical weeding using implements such as push weeder and interrow cultivation weeders.

Read more

The dirty dozen



The 12 most troublesome weeds of rice in Asia

How to manage pests and diseases

Farmers lose an estimated average of 37% of their rice crop to pests and diseases every year. In addition to good crop management, timely and accurate diagnosis can significantly reduce losses. If you are facing a problem in your crop and need help with diagnosis, seek advice from a professional or use the Rice Doctor.

If you have a problem in your field and you're not sure what it is, go to the Rice Doctor

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Crop problems can be caused by other living organisms, like rats and fungus, or by non-living factors, such as wind, water, temperature, radiation, and soil acidity.

The best control for pests and disease problems is prevention. **To limit pest and disease damage:**

STEP 1 Practice good cleaning of equipment and field between seasons

STEP 2 Use clean seeds and resistant varieties

STEP 3 Plant at the same time as your neighbors

STEP 4 Do not over apply fertilizer

STEP 5 Encourage natural pest enemies

STEP 6 Do not apply pesticide within 40 days of planting

STEP 7 Properly store grain

Did this page help you?

Rats

In Asia, rats cause an average of 5−10% loss in rice yield every year. Rats breed at an alarming rate when food is abundant. One female rat can produce

35 rats in a season. Rat management is critical before the breeding cycle, otherwise, the population can explode and yields will be greatly reduced.

Read more

Insects

More than 100 species of insects are considered pests in rice production systems globally, but only about 20 species cause significant economic damage. The recommended control of insect pests is to develop and follow an Integrated Pest Management plan.

Read more

Diseases

Disease damage to rice can greatly reduce yield. They are mainly caused by bacteria, viruses, or fungi. Planting a resistant variety is the simplest and, often, the most cost effective management for diseases.

Read more

Golden Apple Snail

The golden apple snail was introduced into Asia during the 1980s from South America as a potential food for people. Unfortunately, the golden apple snail has become a major pest of rice having spread to the Philippines, Cambodia, Thailand, and Vietnam.

Read more

Birds

Birds are considered to be a pest of rice but little is known about exactly how much damage is caused by birds. Only a few species of birds are grain eaters and others eat insects, worms, or snails.

Read more

Nematodes

Nematodes such as the root-knot nematode infect plant roots, causing root knot galls that drains the plant's photosynthate and nutrients. It can even cause complete yield loss.

Read more

Postproduction

Harvesting

Harvesting is the process of collecting the mature rice crop from the field. Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling.

Storage

The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi.

By-products

The main by-products of rice are rice straw, rice husks or hulls, and rice bran. With proper management, each by-products can be utilized for better purposes such as for energy and non-energy uses (e.g., for agriculture sector and animal fodder production).

Drying

Drying is the process that reduces grain moisture content to a safe level for storage. It is the most critical operation after harvesting a rice crop. Delays in drying, incomplete drying, or ineffective drying will reduce grain quality and result in losses.

Milling

Milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities.

Harvesting

Harvesting is the process of collecting the mature rice crop from the field. Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling. These can be done individually or a combine harvester can be used to perform the operations simultaneously.

It is important to apply good harvesting methods to be able to maximize grain yield, and minimize grain damage and quality deterioration.

Harvesting processes

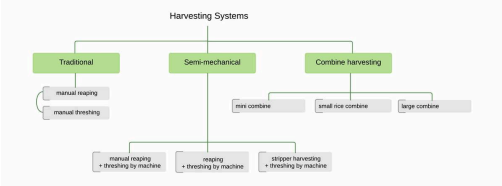
Harvesting rice consists of the basic operations which can be done in individual steps or in combination using a combine harvester. These include:

- Reaping - cutting the mature panicles and straw above ground
- Threshing - separating the paddy grain from the rest of cut crop
- Cleaning - removing immature, unfilled, non-grain materials
- **Hauling** - moving the cut crop to the threshing location
- **Field drying** - leaving the cut crop in the field and exposing it to the sun for drying *(optional)*
- **Stacking/piling** - temporarily storing the harvested crop in stacks or piles *(optional)*
- **Bagging** - putting the threshed grain in bags for transport and storage

Traditional harvesting activities such as field drying and stacking/piling are not recommended because they can lead to rapid quality deterioration and increased harvest losses.

Besides these, a variety of other activities can be included in harvesting such as gathering, reaping (gathering standing grain by cutting), bundling, and various forms of transporting the crop and grain.

Harvesting systems



Click to zoom

Harvesting systems vary from region to region. A wide variety of traditional and semi-mechanical tools, or combine harvesters may be used.

The most common harvesting systems are:

- **Manual harvesting and threshing**
  - uses traditional tools such as sickles, knives, threshing racks, simple treadle threshers, and animals for trampling
- **Manual reaping and mechanical threshing**
  - manual harvesting by hand; uses portable thresher or small stationary machine threshers

- **Reaping followed by machine threshing**
  - uses a reaper, threshing by a thresher, and cleaning either manually or by machine
- **Combine harvesting**
  - combines all processes: reaping, threshing, and cleaning

Read more »

Guidelines on proper harvesting

Regardless of the harvesting system used, it is important to ensure that good grain quality is preserved during harvest operations and harvest losses are kept to minimum.

To properly harvest your crops, make sure to:

1. Harvest at the right time with the right moisture content.
    - Correct timing is crucial to prevent losses and ensure good grain quality and high market value. Grain losses may be caused by rats, birds, insects, lodging, and shattering.

- Harvesting too early results in a larger percentage of unfilled or immature grains, which lowers yield and causes higher grain breakage during milling.
- Harvesting too late leads to excessive losses and increased breakage in rice.
- Harvest time also affects the germination potential of seed.

2.  **When to harvest**

   Depending on the growth duration of the variety, harvesting time should be around 110−120 DAS for direct seeded rice, and 100−110 DAT for transplanted rice.

   To determine if the crop is ready for harvest, check for the following indicators:

   - **Moisture content**
     Grain moisture content ideally is between 20 and 25% (wet basis). Grains should be firm but not brittle when squeezed between the teeth.
     Harvest at minimal surface moisture (e.g. from previous rainfall or early morning dew).
     Read: Measuring moisture content in harvesting
   - **Ripe grains per panicle**
     Harvesting should be done when 80−85% of the grains are straw colored (i.e., yellow-colored).
   - **Number of days after sowing**
     Generally the ideal harvest time lies between 130 and 136 days after sowing for late-maturing variety, 113 and 125 for medium duration, and 110 days for early-maturing varieties.
   - **Number of days after heading**
     For dry season harvesting, an optimum time is 28−35 days after heading (emergence of panicle tip from leaf sheath). In wet season harvest, optimum time is 32−38 days after heading.
3. Avoid delays in threshing after harvesting.
   Threshing should be done as soon as possible after cutting to avoid rewetting and to reduce grain breakage.
4. Use proper machine settings when using a threshing machine.
5. Clean the grains properly after threshing.
6. Dry the grains immediately after threshing.

Read: Health and safety precautions during harvesting

Did this page help you?

Harvesting systems

Harvesting systems vary depending on location or region, and can be done using a wide variety of traditional, semi-mechanical, and mechanical tools.

Read more

Harvesting costs

It is useful to evaluate the harvesting cost of paddy since it can make up a significant portion of the production cost of rice.

Read more

Reaping

Reaping or cutting is the first operation in harvesting. Depending on the crop's condition, and availability of labor or machinery, cutting can be done either manually or mechanically.

Read more

Threshing

Threshing is the process of separating the grain from the straw. It can be either done by hand, by using a treadle thresher or mechanized.

Read more

Measuring moisture content

Different moisture contents are required per postproduction operation. These should be followed to ensure good quality of paddy.

Read more

Cleaning

Grain cleaning will improve the drying, the storability of grain, reduce dockage at time of milling, and improve milling output and quality; while, seed cleaning will reduce damage by disease, and improve yields.

Read more

Combine harvesting

Combine harvesting *combines* several operations into one: cutting the crop, feeding it into threshing mechanism, threshing, cleaning, and discharging rain into a bulk wagon or directly into a bags.

Read more

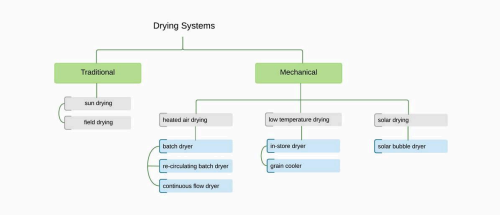
FAQs on harvesting

Find out answers to frequently asked questions about harvesting.

Drying

 Drying reduces grain moisture content to a safe level for storage. It is the most critical operation after harvesting a rice crop.

When rice is harvested, it will contain up to 25% moisture. High moisture level during storage can lead to grain discoloration, encourage development of molds, and increase the likelihood of attack from pests. It can also decrease the germination rate of the rice seed.



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It is important to dry rice grain as soon as possible after harvesting— ideally within 24 hours. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses.

Paddy drying methods include traditional and mechanical systems with varying technological complexity and capacities for either farm or commercial level.

Traditional drying systems

Traditional drying systems are still practiced in many areas because of its low cost and ease of management. These include methods, such as:

- Sun drying - spreading grains under the sun, on mats and pavements
    - **Mat drying** - used in small to medium-scale drying where threshed grain are placed on mats, nets, or canvas
    - **Pavement drying** - often used in large-scale drying for grain collectors and millers, where grains are laid on pavements specifically made for drying
- Field drying and stacking - a method for pre-drying hand-harvested crops before threshing where farmers cut rice panicles in the field and stacked them in small piles on top of the crop stubble

> Although field drying and stacking is still practiced in some areas, it is not recommended because it can lead to high losses when grains become overdried and shattered.

Read more »

Mechanical drying systems

In this system, mechanical dryers are used to remove water from wet grains by forcing either ambient air or heated air through the grain bulk. This is done through:

- Heated air drying - employs high temperatures for rapid drying. The drying process is terminated when the desired final moisture content is reached. It uses the following types of dryer:
    - **Batch dryer** - can be used by farmers, contractors, and small rice mills
    - **Re-circulating batch dryer** - can be used by commercial rice mills and cooperatives
    - **Continuous flow dryer** - not very common, but used by some larger billing enterprises that handle large volumes of wet paddy
- Low-temperature drying or in-store drying - controls the relative humidity rather than the temperature of the drying air so that all grain layers in the deep bed reach equilibrium moisture content. This can be done using the
    - **In/store dryer** - produces very high quality grains but requires long drying time, i.e., four days to two weeks

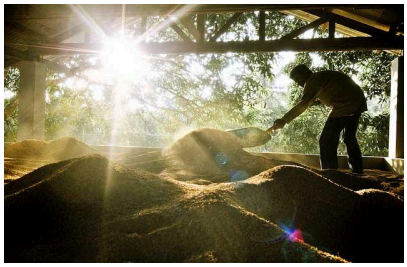
Read: Heated air drying versus low-temperature drying

- Solar drying - latest drying technology that is able to simulate sun drying even during rainy conditions. This is done through:
    - **Solar bubble dryer** - can be locally-built and used by smallholder farmers
- **Grain cooling** - cools the grain to safe storage conditions instead of drying it, allowing grains to be conserved for longer periods

Read: Safety considerations in mechanical drying

Read more »

Guidelines on proper drying


Proper drying can produce high-quality grains. To do this:

- Clean the grains before drying to avoid uneven drying and wet spots.

- Dry paddy grains within 12– 24 hours after cutting as even short-term storage of high moisture grain can cause quality deterioration. Grains should be dried to a certain moisture content (MC) depending on storage period to avoid potential problems:

Storage period	Required MC for safe storage	Potential problems
weeks to a few months	14% or less	molds, discoloration, respiration loss insect damage, moisture adsorption
8–12 months	13% or less	insect damage
storage of farmer's seeds	12% or less	loss of germination
<1 year	9% or less	loss of germination

Note: The final moisture content depends on the relative humidity of the air that surrounds the grain. For long-term storage of grain and seed in tropical climates, it is crucial to prevent rewetting of grain by humid air.

Read: Rice grain and air properties

- Store grains in a safe environment after drying.
- When drying for milling, maintain the MC to 14% so the grain weight and milling yield will not decrease.
- Do not mix grains maintained at different MCs to avoid cracking.
- Always monitor the grain temperature and MC to prevent the grains from being exposed to excess temperatures and over-drying.

Drying systems

Drying can be done using either traditional or mechanical drying systems.

Read more

Drying basics

Since drying practices can have a big impact on grain quality or seed quality, it is important to understand some fundamentals of grain drying.

Read more

Drying strategies

When developing a drying strategy, it is important to consider other activities in rice post production system, and look into the economic criteria

Read more

The Solar Bubble Dryer

Solar drying is the latest in drying technology. In this method, sun drying is simulated using a solar bubble dryer which protects the grains despite changes in weather patterns and thus, prevents postharvest losses.

Read more

In-store drying

In in-store drying, the drying process continous until it reaches the equilibrium moisture content; thus, over drying of the bottom layer is minimized.

Read more

Sun drying

Sun drying is a traditional drying method for reducing the moisture content of paddy by spreading the grains under the sun.

Read more

Economic aspects of drying

A guide to site-specific assessment on the potential of mechanical drying

Read more

Measuring moisture content

Different moisture contents are required per postproduction operation. These should be followed to ensure good quality of paddy.

Read more

Heated air drying

Heated air drying allows for suitable drying air conditions to be set. In this method, drying can be carried out any time of the day or night.

Read more

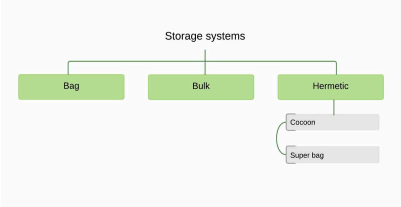
Storage

 The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi.

In general, it is recommended that rice for food purposes be stored in paddy form rather than milled rice as the husk provides some protection against insects and helps prevent quality deterioration.

However, when rice can be stored as brown rice, 20% less storage capacity will be needed. **Brown rice** is rice grain with its hulls removed but not polished. Under tropical conditions brown rice has a very short shelf life, approximately two weeks.

Storage systems



Rice storage facilities take many forms depending on the quantity of grain to be stored, the purpose of storage, and the location of the store.

Storage systems can be through bag, bulk, or hermetic containers.

- Bag storage- grain is stored in 40−80 kg bags made from either jute or woven plastic
- Bulk storage - grain is stored in bulk at the farm or at commercial collection houses
- Hermetic storage - grain is stored in an airtight container so that that moisture content of the stored grain will remain the same as when it was sealed. These storages can extend germination life of seeds, control insect grain pests, and improve headrice recovery. Examples include:
    - IRRI Superbag - available to farmers and processors at low cost
    - Cocoon - commercially available
    - Other locally available containers - useful in rural settings, where local containers can be easily converted into hermetic storage systems

Read more »

Guidelines for safe storage

Good storage systems include (1) protection from insects, rodents and birds, (2) ease of loading and unloading, (3) efficient use of space, (4) ease of maintenance and management, and (5) prevention of moisture re-entering the grain after drying.

Safe storage of rice for longer periods is possible if three conditions are met:

1. Grain is maintained at moisture levels of 14% or less and seed is stored at 12% or less
2. Grain is protected from insects, rodents and birds
3. Grain is protected from re-wetting by rain or imbibing moisture from the surrounding air

The longer the grain needs to be stored, the lower the required moisture content will need to be. Grain and seed stored at moisture contents above 14% may experience the growth of molds, rapid loss of viability and a reduction in eating quality.

Good hygiene in the grain store or storage depot is important in maintaining grain and seed quality. To maintain good hygiene in storage:

- Keep storage areas clean. This means sweeping the floor, removing cobwebs and dust, and collecting and removing any grain spills.
- Clean storage rooms after they are emptied and this may include spraying walls, crevices and wooden pallets with an insecticide before using them again.
- Placing rat-traps and barriers in drying and storage areas. Cats deter and help control rats and mice.
- Inspect storage room regularly to keep it vermin proof.
- Inspect the stored seeds once a week for signs of insect infestation. When necessary and only under the direction of a trained pest control technician, the storage room or the seed stock may be sealed with tarpaulin and treated with fumigants.

Specific challenges in the humid tropics

Rice grain is hygroscopic and in open storage systems the grain moisture content will eventually equilibrate with the surrounding air at the so called equilibrium moisture content (EMC). High relative humidity and high temperatures typical for the humid tropical climate lead to grains absorbing water in storage and to a high final moisture content.

In many tropical countries, the equilibrium moisture content is above safe storage moisture levels.

Storage systems

Rice can be stored in bags, bulk, or hermetic containers.

Read more

Storage pests

Storage pests cause losses through a combination of feeding, spoiling and contamination of both paddy and milled grain.

Read more

Cocoon

The Cocoon™ is a commercially available hermetic storage container that consists of two plastic halfs that are joined together with an air-tight zipper.

Read more

Measuring moisture content

Different moisture contents are required per postproduction operation. These should be followed to ensure good quality of paddy.

Read more

IRRI Super Bag

The IRRI Super bag makes the principle of hermetic storage available to farmers and processors at low cost.

Read more

Using local containers

In local markets there are available containers that can be easily converted into a hermetic storage system.

Read more

FAQs on storage

Answers to frequently asked questions on storage

Milling

Milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities.

Depending on the requirements of the customer, the rice should have a minimum number of broken kernels.

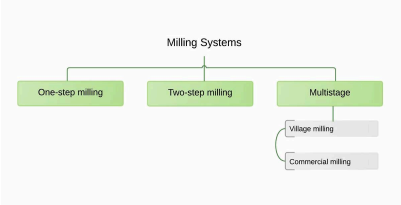
The rice kernel composition

Most rice varieties are composed of roughly 20% rice hull or husk, 11% bran layers, and 69% starchy endosperm, also referred to as the total milled rice.

In an ideal milling process this will result in the following fractions: 20% husk, 8−12% bran depending on the milling degree and 68−72% milled rice or white rice depending on the variety. Total milled rice

contains whole grains or head rice, and brokens. The by-products in rice milling are rice hull, rice germ and bran layers, and fine brokens.

Milling systems



A rice milling system can be a simple one or two step process, or a multi stage process.

- **One step milling -** husk and bran removal are done in one pass
- **Two step process -** removing husk and removing bran are done separately
- **Multistage milling -** can be done in the village or local consumption or commercially for marketing rice; rice undergoes a number of different processing steps, such as:
    1. Pre-cleaning
    2. Dehusking or dehulling
    3. Paddy separation
    4. Whitening or polishing
    5. Grading and separation of white rice
    6. Mixing
    7. Mist polishing
    8. Weighing of rice

Guidelines for good milling

The best quality rice will be attained if the quality of paddy is good and the rice is milled properly. To improve the quality of the rice, factors such as the paddy quality and milling technology should be considered.

To obtain good paddy quality:

-  **Mill at the right moisture content (MC)**
  A moisture content of 14% MC is ideal for milling.
  If the MC is too low, high grain breakage will occur resulting in low head rice recovery. Broken grain has only half the market value of head rice. Use a moisture meter to determine the moisture content. Visual methods are not accurate enough.

  Read: Moisture content for milling

  
- **Pre-clean paddy before husking**
  Use of paddy without impurities will ensure a cleaner and higher quality end product.
- **Do not mix varieties prior to milling**
  Different varieties of paddy have different milling characteristics that require individual mill settings. Mixing varieties will generally lead to lower quality of milled rice.

Read: Producing good quality milled rice

When using milling technology:

- **Use rubber roll technology for husking**
  Rubber roll huskers produce the best quality. Engleberg-type or "steel" hullers are no longer acceptable in the commercial rice milling sector, as they lead to low milling recovery and high grain breakage.
-  **Use a paddy separator**
  Separate all paddy from the brown rice before whitening. Paddy separation after husking will lead to better quality milled rice, and reduce overall wear and tear on the rice mill.
- **Consider two-stage whitening**
  Having at least two stages in the whitening process (and a separate polisher) will reduce overheating of the grain and will allow the operator to set individual machine settings for each step. This will ensure higher milling and head rice recovery.
-  **Grade the milled rice**
  Installl a screen sifter to remove small brokens and chips from the polished rice. Rice with a large number of small brokens (or brewer's rice) has a lower market value. The small brokens can be utilized to produce rice flour.
- **Monitor and replace spare parts regularly**
  Turning or replacing rubber rolls, refacing stones, and replacing worn screens regularly will keep milled rice quality high at all times.

Milling systems

A rice milling system can be a simple one or two step process, or a multi stage process.

Read more

Milling by-products

The main by-products of rice are rice husk or hull, rice bran, and brewer’s rice.

Read more

Measuring moisture content

Different moisture contents are required per postproduction operation. These should be followed to ensure good quality of paddy.

Read more

Producing good quality milled rice

To produce quality milled rice, the paddy should be good, equipment well maintained, and the operator should have appropriate skills

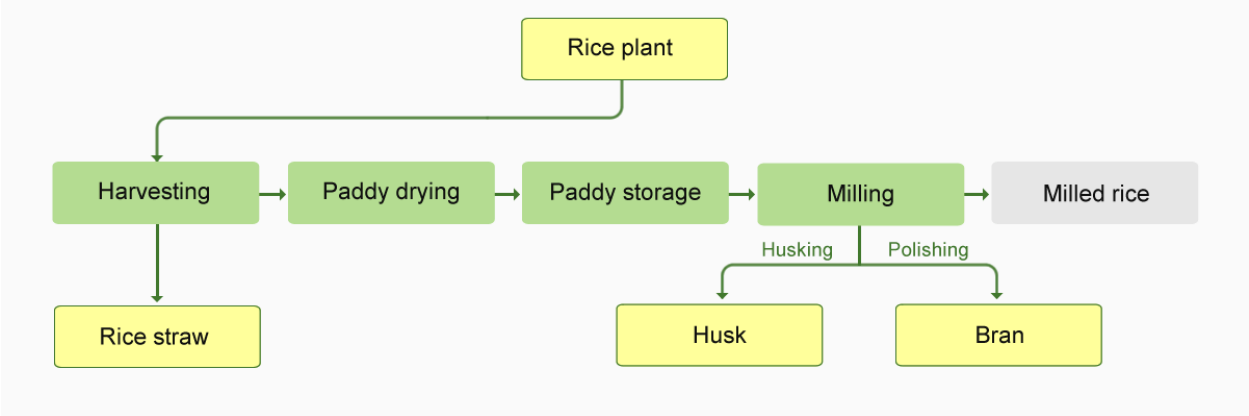
Read more

IRRI Rice Quality Assessment Kit

The IRRI Rice Quality Assessment Kit consists of a set of various tools that help measuring one or several paddy, milled rice or seed quality traits.

By-products

The main by-products of rice are rice straw, rice husk or hull, and rice bran.



- Rice strawis produced when harvesting paddy. Straw comes from what is left on the plant after it is harvested and the grains are threshed.
- Rice husks or hullsare generated during the first stage of rice milling, when rough rice or paddy rice is husked.
- Rice bran is produced during the second stage in milling, the whitening or polishing process, when the bran layer is removed from the brown rice kernel.

Rice straw

What is rice straw?

Rice straw is a rice by-product produced when harvesting paddy. Each kg of milled rice produced results in roughly 0.7–1.4 kg of rice straw depending on varieties, cutting-height of the stubbles, and moisture content during harvest. Rice straw is separated from the grains after the plants are threshed either manually, using stationary threshers or, more recently, by using combine harvesters (Figure 1).

Figure 1. Harvesting grain and straw using the combine harvester.

Read more »

Rice husk

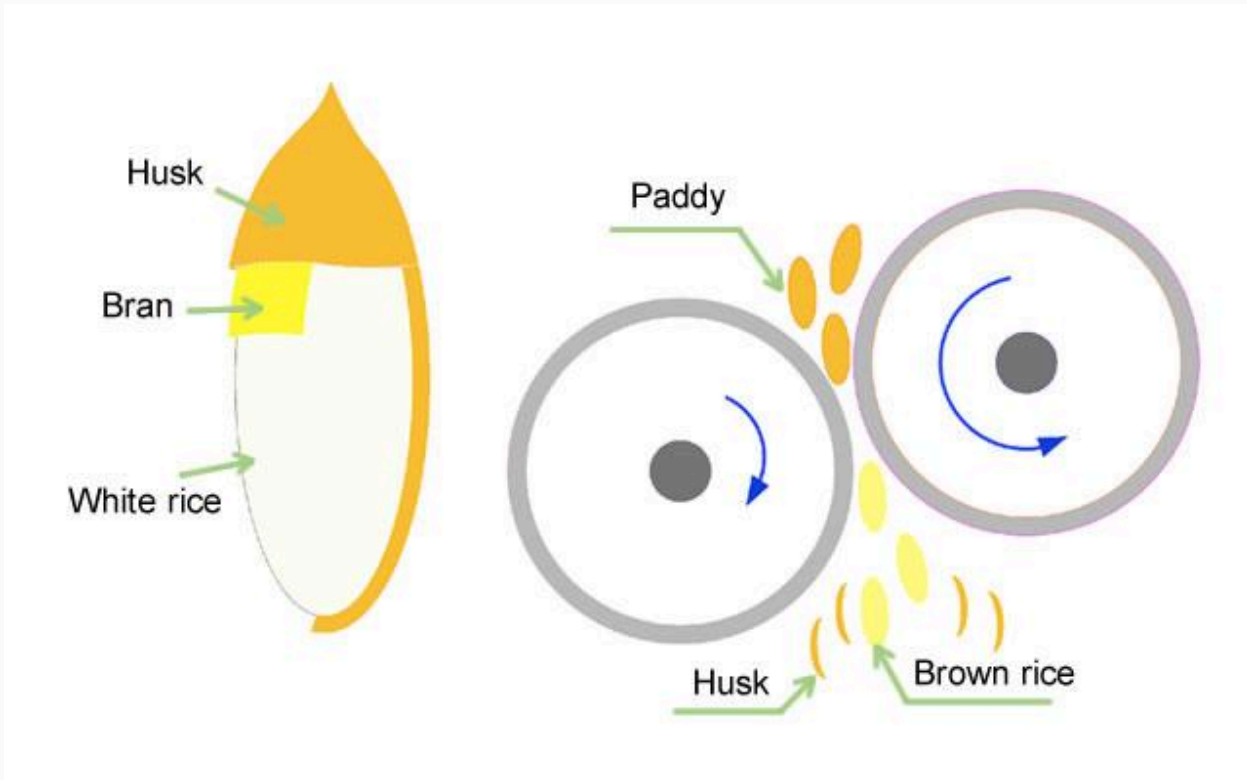


Fig. 1. Paddy grain (left) and its products after husking.

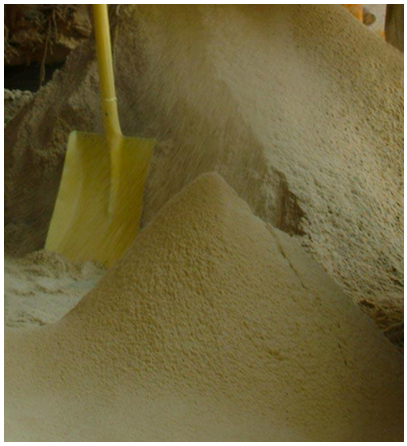
What is rice husk and what are its major products?

The rice husk, also called rice hull, is the coating on a seed or grain of rice. It is formed from hard materials, including silica and lignin, to protect the seed during the growing season. Each kg of milled white rice results in roughly 0.28 kg of rice husk as a by-product of rice production during milling.

Common products from rice husk are: solid fuel (i.e., loose form, briquettes, and pellets), carbonized rice husk produced after burning, and the remaining rice husk ash after combustion.

Read more »

Rice bran

 One hundred kilogram (100 kg) of paddy rice will generate approximately 5−10 kg of bran. Rice bran is a mixture of substances, including protein, fat, ash, and crude fiber. In many cases, bran contains tiny fractions of rice hull, which increases the ash content of bran. Bran composition is largely dependent on the milling process.

In modern rice mills, several different kinds of bran are produced: coarse bran (from the first whitening step), fine bran (from second whitening step) and polish (from the polishing step). Polish consists of part of the endosperm and is often referred to as meal.

Rice bran has a high nutritive value. Besides proteins, rice bran is an excellent source of vitamins B and E. Bran also contains small amounts of anti-oxydants, which are considered to low cholesterol in humans. Rice bran contains 10−23% bran oil. The oily nature makes bran an excellent binder for animal feeds. Bran oil, once stabilized and extracted, is a high quality vegetable oil for cooking or eating. The conventional use of rice bran is as ingredient for animal feeds, in particular ruminants and poultry. In recent years however, advances in stabilization techniques have been made which has led to new uses for bran and its derivatives, most notably bran oil for cooking and waxes for cosmetic products. In the developing countries, rice bran is underutilized due to a lack of suitable stabilization techniques.