Pre Planting Phase

This is the phase where farmers prepare for the establishment of their rice crop. This involves selection of well-adapted rice varieties and good-quality seed, careful land preparation, and proper management of rodents, insects, and crop residues and organic materials.

Selection of Rice Variety

Farmers are encouraged to use locally adapted varieties to ensure good crop establishment and high yield with acceptable grain quality for market.

Essentially, a variety should have:

- suitable grain quality, especially cooking characteristics, color, shape, taste and aroma, and head rice recovery. Head rice recovery is the weight percentage of head rice (whole grains with at least 75% of the whole undamaged milled rice kernel) from a sample of paddy. The quality should be acceptable to farmers and the local market at a price that is acceptable for them.
- adequate yield potential and stability over seasons.
- resistance or tolerance to major diseases, insects, and/or abiotic stresses (e.g., drought and flood) of the area.

The right duration of growth to match the season. Avoid varieties that need to be planted or harvested earlier or later than other surrounding ricefields. In nearby fields, avoid attack from pests (e.g., birds during maturation), and growth problems during times of harmful environmental conditions (e.g., late-maturing varieties running out of water)

- adequate tillering capacity to shade out weeds and produce a sufficient number of tillers for optimum yields.
- resistance to lodging under normal farmer management.

Quality Seed

A seed is a living product that must be grown, harvested, and processed correctly to maximize its viability and subsequent crop productivity. To achieve the yield potential of any rice variety, good-quality seed must be used. Good-quality seed can increase yields by 5–20%.

Good seed is pure (of the chosen variety), full and uniform in size, viable (more than 80% germination with good seedling vigor), and free of weed seeds, seed-borne diseases, pathogens, insects, or other matter.
Using good seed leads to lower seed rate, higher crop emergence (more than 70%), reduced replanting, more uniform plant stands, and more vigorous early crop growth. Vigorous growth in early stages reduces weed problems and increases crop resistance to insect pests and diseases.

Land Preparation

Land preparation typically involves plowing, harrowing, and leveling the field to make it suitable for crop establishment. Draft animals, such as buffalo and oxen, 2-wheel tractors or 4-wheel tractors can all be used as power sources in land preparation. The initial soil tillage can also be performed with a rotovator instead of a plow.

Flooded Soils

The vast majority of Asian rice fields are first flooded with water before tillage. This tillage of flooded soil is referred to as puddling. Soil flooding and soaking is performed once and requires sufficient water to bring the topsoil to saturation and create an overlying water layer. Soil puddling destroys soil structure, which reduces percolation rates and loss of water. It also results in high resistance to root penetration, low porosity, and permeability and in the formation of a soil plow pan; all of which can restrict root growth. Puddling is very efficient in clay soils that form deep cracks penetrating the plow pan at about 15 to 20 cm soil depth during the period of soil drying before land preparation. Although puddling reduces percolation rates of the soil, the action of puddling itself consumes water. There is a trade-off between the amount of water used for puddling and the amount of water “saved” during the crop growth period as a result of reduced percolation rates. Puddling is less effective in coarse soils, which do not have enough fine clay particles to migrate downward and fill up the cracks and pores in the plow pan.

Non Flooded Soil:

A well-leveled field is a prerequisite for good water and crop management. When field are not level, water may stagnate in the depressions whereas higher parts may fall dry. This results in uneven crop emergence and uneven early growth, uneven fertilizer distribution, and possibly additional weeds. Effective land leveling will :

- Improve crop establishment and care,
- Reduce the time and water required to irrigate the field, and
- Ensure more uniform distribution of water in the field

Land preparation for dry seeding typically involves consists of plowing or rotovating followed by harrowing and leveling of dry and friable soil. The crop is established by broadcasting or drilling seed that has not been pre germinated.
Farmers can reduce water use by shifting from puddled to non-puddled land preparation. Large amounts of water (20–40% of total water use) are consumed during land preparation of flooded soils because of the need to initially soak dry and cracked soil, and to keep the field continuously flooded. Most of the wasted water is lost by drainage through soil cracks. Dry land preparation does not require irrigation water because it can be done when the soil has the correct water contact and is friable for plowing or rotovating and harrowing.

Water Management - Pre planting phase

Water management: *Pre planting phase* | *Early vegetative – transplanted rice* | *Late vegetative phase* | *Reproductive phase* | *Ripening phase*

Land preparation for flooded soils consumes more than a third of the total water required for growing rice in an irrigated production system. High water loss during land preparation is caused by water flowing through cracks in the soil.
Seepage and percolation flows from rice fields are major pathways of water loss. A rice field can be compared with a bath tub: The material of a bath tub is impregnable and it holds water well. However, water can run out immediately from even one hole, such a with removing the plug of a bath tub. Rice fields with only a few rat holes or leaky spots will rapidly loose water by seepage and percolation. Thorough puddling results in a good compacted plow pan that reduces percolation rates throughout the crop growing period. The efficacy of puddling in reducing percolation depends greatly on soil properties.
Land preparation lays the foundation for good water management afterwards. Especially important for good water management are:

- Land leveling
- Tillage operations
- Field channels
- Land bund preparation and maintenance

Water saving during land preparation can increase the service area of an irrigation system.

Tillage to reduce water loss

Large amounts of water can be lost during land soaking prior to puddling when large and deep cracks are present that favor rapid by-pass flow to below the root zone. Shallow tillage to fill the cracks before land soaking can greatly reduce the amount of water used in land preparation for flooded soils.

Timely land preparation of flooded soils

Minimizing the turnaround time between land soaking for land preparation and crop establishment reduces the period when no crop is present and the outflows of water from the field (by evaporation, seepage, and percolation) do not contribute to production. Synchronous operations and consequent reduction of the land preparation period (usually around 40 days) can therefore reduce water use.

In large-scale irrigation systems with plot-to-plot irrigation, the water losses during the turnaround time can be very high when a large area is flooded to provide water to small seed beds scattered throughout the area. The turnaround time can be minimized by the installation of field channels, the adoption of common seed beds, synchronized planting, or the adoption of direct wet or dry seeding. With field channels, water can be delivered to the individual seed beds separately and the main field does not need to be flooded. Common seed beds, either communal or privately managed, can be located strategically close to irrigation canals and be irrigated as one block.

Field channels to manage water

In many irrigation systems in Asia, there are no field channels or 'tertiary' irrigation or drainage channels. Water flows from one field into the next through breaches in the bunds. With such plot-to-plot irrigation the amount of water flowing in and out of a rice field cannot be controlled and field-specific water management is not possible. Farmers might be unable to obtain irrigation water if upstream farmers retain water in their fields, or they might be unable to drain their fields before harvest if irrigation water keeps flowing into their field from upstream fields. The water continuously flowing through rice fields can also remove valuable nutrients form added fertilizer.

The construction of separate channels to convey water to and from each field or and from to a small group of fields greatly improves the control of water by individual farmers. It is the recommended practice in any type of irrigation system.

Bund preparation and maintenance

Good bunds are a prerequisite to limit water losses by seepage and underbund flows. Bunds should be well compacted and cracks or rat holes should be plastered with mud at the beginning of the crop season to limit water loss by seepage. Bunds should be high enough (at least 20 cm) to avoid overbund flow during heavy rainfall. Lower levees of 5-10 cm height in the bunds can be used to keep the ponded water depth at that height. These levees can be heightened with soil when more stored water is needed in a rice field.

Rodent Management - Pre planting phase

Rodent management: Pre planting phase| Early vegetative – wet-seeded | Late vegetative phase | Reproductive phase | Ripening phase | Postproductive phase

During land preparation, rats usually take refuge in vegetation near major irrigation canals, in village gardens, and in other non-crop areas which provide good cover. When rats are concentrated in these habitats, it is the best time to organize community rat control campaigns. These rat campaigns can be done until three weeks after planting.

Effective community control actions include

(i) flooding, digging or fumigation of rat burrows,
(ii) rat drives through areas with high vegetation cover or around villages (using netting, dogs, clubs, and others to catch rats),
(iii) using dogs to locate active rat burrows, then applying the actions described in (i),
(iv) hunting of rats at night using flashlights, clubs, bow and arrows, and netting,
(v) local kill-traps set along runways of rats, and,
(vi) strategic use of registered rat poisons placed in covered bait stations (but not where livestock and children have easy access). Note that effective community campaigns will need little, if any, poisons.

Other important management actions:

- Synchronize planting of crops with neighbors—within 2 weeks of each other.
- Keep rice bunds (banks) in the crops less than 30 cm wide where possible.
- Reduce vegetation along edges of rice fields.
- Strategic use of Trap Barrier System (TBS)—during the rice season which suffers most rodent damage.
- Good hygiene around villages—clean up garbage and keep areas around grain stores clear of vegetation, piles of wood, etc.

TIMING OF COMMUNITY RAT CONTROL—EARLY ACTION IS MOST EFFECTIVE, WHEN RATS ARE NOT BREEDING

Rodents take advantage of favorable conditions to breed very quickly. In Indonesia, Malaysia and Vietnam, in lowland irrigated rice, the rice field rat breeds when the rice crop is at the late vegetative stage. If there is one crop per year the rats breed once; if there are two crops per year, the rats breed twice.

Usually, the rats will only produce two or three litters per cropping season, none of which will breed in that season.

The removal of one female rat before she breeds is equivalent to killing 35 rats when the crop is at the ripening phase.

Planting crops more than two weeks apart – a recipe for disaster

If neighboring crops are planted more than two weeks apart, the breeding season will be extended long enough for the first litter to have time to breed, resulting in an explosion of population numbers.

For example, consider a three-week extension to the harvesting period because crops are not planted at the same time. A single female breeding early in the season can give rise to as many as 120 rats feeding on the last crops to ripen.

Traditionally, rodents are only controlled when their numbers are high. This is probably the worst time to deal with the problem!

Note that the major pest species of rat in the Philippines, Laos and parts of Cambodia is different and they are able to breed during most of the year. However, their peak of breeding coincides with the maturing rice crop. So again, early action is the most effective.

In South Asia, the situation is more complicated because of different species of rodent pests. However, the principle of matching control action to the breeding ecology of the rat still applies.

Further reading:

Singleton, G.R., Sudarmaji, Jacob, J. and Krebs, C.J. (2005). Integrated management to reduce rodent damage to lowland rice crops in Indonesia. *Agriculture, Ecosystems and Environment* **107**, 75-82.

Brown, P.R., Tuan, N.P., Singleton, G.R., Ha, P.T.T., Hao, P.T., Tan, T.Q., Tuat, N.V., Jacobs, J. and Müller, W.J. (2006). Ecologically-based management of rodents in the real world: application to a mixed agro-ecosystem in vietnam. *Ecological Applications (In Press)*

General Articles

Roger Beckman: Tougher times for raiders of the ricefield. (ACIAR Partners Newsletter, May 2003)

Adam Barclay: Building a better rat trap. (Rice Today August 2005, pp. 34-35)

Weed Management - Pre planting phase

Weed management: Pre planting phase | *Early vegetative - transplanted* | *Early vegetative - wet-seeded* | *Late vegetative* | *Reproductive phase* | *Ripening phase*

Land preparation

Thorough land preparation should start 3–4 weeks before planting to allow destruction of existing vegetation and drying of weed seeds and other plant parts that can be spread across the field. A thoroughly leveled field allows good establishment and water control. (Stale-seedbed. This technique involves repeated plowing and harrowing before planting. Weeds are allowed to emerge and are then killed by cultivation. This technique is effective in reducing the reserve of weed seeds in the soil, and will greatly reduce weed infestation in the subsequent crop.) (from wet seeded rice)

Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Insect Management - Pre planting phase

Insect management: Pre planting phase | *Early vegetative - transplanted* | *Early vegetative - wet-seeded* | *Late vegetative*| *Reproductive phase* | *Ripening phase*

Development of insect pests during the pre-planting phase is influenced by cultivation practice, cropping pattern, cultivar, planting time, planting method, and water management.

Important management options to consider are:

Cultivation practice. Plowing after harvest removes stubble that serves as remaining food and shelter for most pests, especially insects.

Selection of cultivar. Use of short-duration and resistant cultivars decrease insect pest populations. In short-duration cultivars, insects cannot complete as many generations, so populations may not reach damaging levels. With insect-resistant varieties, a healthier crop growth is obtained because insect populations are low. Resistant varieties experience less feeding damage—which creates entry points for bacteria and fungal diseases—on their leaves and stems.

Water management. Periodic draining and flooding of the field decreases numbers of virus vectors (insects and animals that carry and transmit viruses), virus disease infection, and soil-inhabiting insects

Nutrient management - Residue Management

Nutrient management: Pre planting phase (residue management | *organic materials and manure management)* | *Early vegetative - transplanted* | *Early vegetative - wet-seeded* | *Late vegetative* | *Reproductive phase* | *Ripening phase*

Composting rice residue

Composting converts crop residues into a better organic fertilizer. Compost is the relatively stable product that results after organic materials such as crop residues and animal manure decompose. It usually contains relatively low amounts of major nutrients such as nitrogen (N) and phosphorus (P). In general, carbon (C) is reduced while other nutrients are concentrated during composting. Although organic fertilizers such as rice compost are often low in major nutrients, they can be highly beneficial because they contain micronutrients, enzymes, and microorganisms that are often not found in inorganic fertilizers. Rice straw, in particular, is rich in potassium (K).

Other advantages of composting:

- Composting concentrates the nutrients in otherwise poor quality rice by-products.
- Nutrients in compost are released slowly and are less likely to be lost by leaching.
- The high temperatures generated in composting (above 55ºC) keep pathogen levels low and reduce the viability of weed seeds contained in the compost material.
- Once compost is ready to use, it is easy to handle (it is fairly stable and has little odor).
- Organic wastes are widely available on farms.

Organic Materials and Manure Management

Nutrient management: Pre planting phase (residue management | organic materials and manure management) | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

Organic materials and manures

Organic material and manures are those materials that come from plant or animal waste or by-products such as cattle or poultry manure, composted rice straw or other crop residues, sewage sludge, oil cakes, green manures, and legume clippings.
Organic material or manure is usually applied uniformly across the field, two or more weeks before being incorporated into the soil during land preparation. Sometimes, rice straw is directly composted in the field.
Manures and other organic sources are used to improve soil fertility and soil organic matter content, and to provide micronutrients and other growth factors not normally supplied by inorganic fertilizers. Application of these materials may also enhance microbial growth and nutrient turnover in soil.
It is advisable to combine the use of organic manures with the application of inorganic nutrient sources as needed. This allows farmers to use organic materials or manure available on-farm at low cost to supply a portion of the crop’s demand for nutrients and improve soil fertility where required. The use of organic manures available on-farm can return high yields and profit when combined with inorganic fertilizer, particularly on upland or poor lowland soils. However, it is often not profitable to buy organic fertilizers even if they are sold as fortified organic fertilizers, which is a ready mix of organic and inorganic fertilizers.

Early Vegetative Phase

(from germination to tillering)

The vegetative phase starts at seed establishment (germination) and ends at the onset of panicle initiation, during the late vegetative phase. The number of days in this phase varies in different varieties. For example, the 120-day rice variety will have 55 days in the vegetative phase, while the 150-day variety may take 85 days. Further, low temperature or long day length can increase the duration of the vegetative phase.

Transplanted Rice

In transplanting rice, seedlings are first grown in seedbeds before they are transplanted in the fields.

Nursery management

Plant population and seedling age

For a mat nursery density of 3000 seeds per square meter and above, the ideal transplanting age is around 10 days (or 4-leaf stage), to avoid competition. Also, early transplanting at 10 days allows a smaller nursery area, even if density is high.

For conventional nursery, transplanting can be done later, up to about 21 days after sowing (or 7-leaf stage), but a larger area should be used to allow a seedling density lower than 1000 seeds per square meter.

Reducing the time seedlings spend in the nursery from 20 to 10 days (seeding at 3000 seeds per square meter in the nursery) can increase yields by as much as 1 ton per hectare.

There are two choices in establishing seedling nurseries: Reduced Area Wet-Bed Nursery and Modified Mat Nursery.

To see the details of Reduced Area Wet-Bed Nursery, click here.
To see the details of Modified Mat Nursery, click here.

Crop Establishment

Early tiller emergence and quick leaf area coverage in the main field are necessary to achieve high yields in intensive lowland irrigated rice fields. This primarily requires growing adapted genotypes with an early growth strategy of producing many tillers quickly, and developing a high leaf area rather than a small leaf area with strong and thick blades and stems. This is the case for most newly bred genotypes for irrigated systems, including both hybrids and inbreds, but not the case for plants with a low tillering ability like new plant types and low tiller gene introgression lines.

Hill density of 25 hills per square meter is usually sufficient. Transplant 1-2 seedlings per hill for mat nursery-raised seedlings and 2-3 seedlings per hill for conventionally raised seedlings, in case one seedling dies. More than this can create too much competition among seedlings, leading to reduced vigor.
(from transplanted rice definition)

Water Management - Transplanted Rice

Water management: Pre planting phase | Early vegetative – transplanted rice | Late vegetative phase | Reproductive phase |Ripening phase

After crop establishment, continuous ponding of water generally provides the best growth environment for rice and will result in the highest yields. After transplanting, water levels should be around 3 cm initially, and gradually increase to 5-10 cm with increasing

plant height.
In case of water scarcity, apply water-saving technologies such as alternate wetting and drying (AWD) , saturated soil culture (SSC), direct dry seeding, or any other technologies as find in the link…[How to manage water scarcity?]

Nutrient Management - Transplanted Rice

Nutrient management: Pre planting phase (residue management | organic materials and manure management) | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

From 2 days before transplanting to 14 days after transplanting (DAT), apply:

- Only a moderate amount of nitrogen (N) fertilizer, because the rice plant's need for supplemental N is small during this period of slow initial plant growth.
- All of the required phosphorus (P) fertilizer, because P is important for early crop growth, especially for root development and tillering.
- At least half of the required potassium (K) fertilizer, because K contributes to greater canopy photosynthesis and crop growth.
- All of the required zinc (Zn) and sulfur (S) fertilizer.

Nitrogen (N)

Use the following general guidelines to determine the early application of N before 14 DAT:

- Typically apply 20–30 kilograms of N per hectare in seasons when yield response to N is between 1 and 3 tons per hectare.
- Apply 25–30% of the total N in seasons when yield response to N is greater than 3 tons per hectare.
- Eliminate early application when yield response to N is less than or equal to 1 ton per hectare.
- Do not use the Leaf Color Chart (LCC) with early N application.
- Reduce or eliminate early N application when high-quality organic materials and composts are applied or the soil has a high existing N content.
- Increase N application to 30–50% of the total N when older seedlings (more than 24 days old) and short-duration varieties are used.
- Increase early N application in areas with low air and water temperature at transplanting, and for low-tillering and large-panicle varieties.

Phosphorus (P)

As a general rule for modern rice varieties with harvest indices of 0.45–0.55, when most of the crop residue is retained in fields after harvest and little or no manure is applied to fields, apply 4 kilograms of P_2O_5 per hectare per ton of grain harvested to replenish the P_2O_5 used by the previous season's crop (for example, 20 kilograms P_2O_5 per hectare for a grain yield of 5 tons per hectare). When all crop residues are removed from fields after harvest and there is little or no P added from organic fertilizer (such as manure) is negligible, apply about 6 kilograms of P_2O_5 per hectare per ton of grain harvested to replenish the P_2O_5 used by the previous season's crop (for example, about 30 kilograms P_2O_5 per hectare for a grain yield of 5 tons per hectare).
Harvest index. The ratio of grain weight to total aboveground plant dry weight.

Potassium (K)

Apply about 3.5 kilograms of K_2O per hectare per ton of grain harvested to match the export of K_2O with harvested grain when all crop residues are retained in fields after harvest. For example, apply about 17.5 K_2O per hectare for a grain yield of 5 tons per hectare. When all crop residues are removed from fields after harvest, apply about 12 kilograms of K_2O per hectare per ton of grain harvested to match the net export of K_2O with harvested grain and straw and maintain soil K fertility. For example, apply about 60 K_2O per hectare for a grain yield of 5 tons per hectare.
When the total K fertilizer requirement is relatively low (less than or equal to 30 kilograms of K_2O per hectare), apply all K fertilizer before 14 DAT. On sandy soils or when larger amounts of K fertilizer are required, apply about 50% of the required K fertilizer before 14 DAT.

Sulfur (S)

If the soil is deficient in S, apply about 2.5–3 kilograms of S per hectare per ton of anticipated crop yield before 14 DAT.

Zinc (Zn)

If the soil is deficient in Zn, apply about 5 kilograms of Zn per hectare as zinc sulfate before 14 DAT. Alternatively, apply zinc sulfate in the nursery seedbed, or dip seedlings in 2–4 % zinc oxide suspension before transplanting.

Weed Management - Transplanted Rice

Weed management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Weeds should be controlled during the first 30–40 days after sowing or transplanting (DAS/DAT). This is the period where weed competition is greatest and can greatly reduce yield. Crop management and appropriate cultural measures (activities or operations carried out in raising field crops, e.g., land preparation, seed selection, crop establishment, and fertilization) should be done before planting to reduce weed growth in the subsequent crop.

1. Nursery beds should be free of weeds to avoid transplanting weed seedlings together with rice seedlings (particularly with conventional nursery beds). If nursery beds have weeds, weed seedling should be separated from rice seedlings during pulling and bundling.
2. In the field, if grass weeds are likely to be the main weed problem, apply pre-emergence herbicide (e.g., pretilachlor or butachlor at 3-4 DAT) or early post-emergence herbicide (e.g., butachlor + propanil 6–10 DAT, or cyhalofop butyl 8–15 DAT. Click here to see the list of pre-emergence and early post-emergence herbicides. Do not allow soil surface to dry after transplanting. Keep the soil moist to saturated. A dried soil surface will reduce the performance of pre-emergence herbicides. Flood the field 1 day after application of pre-emergence herbicide.
3. Maintain a 5–7 cm water depth to prevent germination of weeds until 7–10 days before harvest.
4. If the rice is planted in rows, mechanical weeding using a rotary or push weeder may be done. Maintain shallow flooding 7-10 DAT drain the field then pass rotary/push weeder crosswise to bury emerged weed seedlings. Leave the field at saturation for 2 days to keep the buried weed seedling in the mud layer then flood the field up to 5 cm of water.

Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Insect Management - Transplanted Rice

Insect management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

During this phase, rice plants usually compensate for any damage caused by insect pests, especially by defoliators (any chewing insect that feeds on the leaves of plant). Rice plants can develop new leaves after serious injuries by defoliators. Checking the crop for damage allows farmers to determine possible causes.

Important management options to consider are

Water management. Periodic draining and flooding of the field decreases numbers of virus vectors, virus disease infection, and soil-inhabiting insects.
Fertilizer management. High nitrogen application makes rice plants more attractive to insect pests and diseases. Using a leaf color chart helps farmers determine the optimum level of nitrogen required by the crop. Splitting nitrogen application between transplanting and panicle initiation decreases fungal diseases and insects that attack the rice crop. Nitrogen application also favors weed growth. Before nitrogen application, the crop should be weeded first, because any existing weeds will compete with rice for available nutrients.
Weed management. Aside from competing with rice for nourishment, weeds serve as an alternate host of insect pests and pathogens. However, weeds also shelter natural enemies of insect pests. Therefore, although weeds should be removed from inside the field, maintaining some weeds around the outside of the rice field can provide refuge for the natural enemies.
Biological control. Naturally occurring biological control agents such as parasitoids and predators of insect pests can be conserved by minimizing the use of insecticides. Pesticides indiscriminately kill these natural enemies and cause ecological disruptions in natural biological control processes. Insecticide use can promote problems with secondary pests, such as brown planthopper.
Cropping pattern: Synchronous planting vs. asynchronous planting over a given area.

Planting at the same time (synchronous planting) is a good way to avoid insect pest damage. Asynchronous planting of nearby fields favors all insect pests. When a field matures, insect pests that developed in that field move to younger adjacent fields, thereby increasing incidence of pest damage.

Planting time

Early planting effectively controls insect pests. Late planting, which is a source of food and cover, increases pest occurrence.

Planting method:
Transplanting. In transplanted fields, insects, bacteria, and weeds presentfewer problems than in direct-seeded fields.

Snail Management - Transplanted

Snail management: Early vegetative - transplanted | *Early vegetative - wet-seeded*

The golden apple snail [*Pomacea canaliculata Lamarck*] 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.

The golden apple snail eats young and emerging rice plants and can completely destroy a crop during crop establishment.

The critical time to control golden apple snail is during the first 10 days for the transplanted crops and the first 21 days for direct wet-seeded crops. After this, the crop growth is typically greater than the rate of snail damage.

The golden apple snail can be managed through biological, cultural, and chemical controls. One biological control is introducing ants that feed on the snail eggs and ducks that eat the young snails.

Cultural control methods include handpicking snails and crushing egg masses, placing leaves that attract snails, good land leveling and field drainage, and constructing canals. Placing toxic plant leaves, building a bamboo screen on the irrigation water inlet and outlet, and planting vigorous seedlings are also ways to manage golden apple snails. Chemical control can also be used at times when other practices fail.

Wet Seeded Rice

It is a method of planting rice wherein the seeds are sown directly onto puddled soil.

Crop Establishment

Plant populations

Seed rate can be between 50–100 kg seeds per hectare. Higher seeding rates are used to compensate for poor land preparation and damage due to snails, birds, and rats. Increasing the seeding rate may not necessarily increase yield. Under good management practices (good land preparation, water management, and fewer rat and snail problems), a lower seeding rate can be used.

Sowing methods

Seeds can be sown either by broadcasting or by drum seeder (for row-seeding).

Broadcast seeding

Drum seeding

Broadcast seeding	Drum seeding (row-seeding)
Soak seeds for 24 hours.	Soak seeds for 24 hours.
Incubate for 36 hours.	Incubate for 24–36 hours, depending on variety and temperature.
Sow seeds evenly.	Air-dry the sprouted seeds for 10–15 minutes before sowing to facilitate singling/separation of seeds.
	Adjust the holes to the desired seeding rate (e.g., 3 mm radicle length x 28 holes = 60 kg per hectare; the longer the radicle, the lower the seeding rate).
	Fill the drums with seeds up to no more than 2/3 full.
	Walk steadily while pulling the drum seeder.

Row-seeding is more flexible when choosing weed control method. Row-seeding can be done using a drum-seeder. In addition to sowing in rows, drum seeder also reduces the amount of seeds used without reduction in yield compared to broadcast seeding. Click here to know how to use a drum seeder.

Row seeded direct seeded rice

Water Management

With direct wet seeding, the soil should be kept just at saturation from sowing to some 10 days after emergence, and then the depth of ponded water should gradually increase with increasing plant height. With direct dry seeding, the soil should be moist but not saturated from sowing till emergence, else the seeds may rot in the soil. After sowing, apply a flush irrigation if there is no rainfall to wet the soil. Saturate the soil when plants have developed 3 leaves, and gradually increase the depth of ponded water with increasing plant height.

In case of water scarcity, apply water-saving technologies such as alternate wetting and drying (AWD) , saturated soil culture (SSC), direct dry seeding, or any other technologies as find in the link… [How to manage water scarcity?]

Nutrient Management - Wet Seeded Rice

Nutrient management: Pre planting phase (residue management | organic materials and manure management) | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

From 2 days before sowing to 21 days after sowing (DAS), follow the guidelines for the early vegetative phase of transplanted rice. Use the same guidelines to determine the early application of N before 21 DAS:

As a general rule for modern rice varieties with harvest indices of 0.45–0.55, follow the guidelines for the early vegetative phase of transplanted rice.

Weed Management - Wet Seeded Rice

Weed management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Weeds should be controlled during the first 30–40 days after sowing or transplanting (DAS/DAT). This is the period where weed competition is greatest and can greatly reduce yield. Crop management and appropriate cultural measures (activities or operations carried out in raising field crops, e.g., land preparation, seed selection, crop establishment, and fertilization) should be done before planting to reduce weed growth in the subsequent crop.

1. When grass weeds dominate, apply pre-emergence herbicide (e.g., pretilachlor + fenclorim 2–3 DAS) or early post-emergence herbicide (e.g., butachlor + propanil 6–10 DAS, or cyhalofop butyl 8–15 DAS). [Click here to see Table 1 for List of herbicides that may be used for direct-seeded rice in the Philippines (Philrice, 2008).]

2. 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. Late introduction of water beyond 10 days after seeding encourages more weed growth and deeper water level is needed to control weeds.

3. If rice is row-seeded, drain excess water and use rotary or push weeder 10-15 DAS to control weed seedlings. Re-introduce water 1-2 days after to prevent buried and uprooted weeds from recovering. Row seeding by a “drum seeded” helps to ease inter-row cultivation operations and reduces the amount of seed used without reduction in yield compared to broadcast seeding. Click here to see pdf file on how to use drum seeder in sowing pre-germinated rice.
Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Direct-seeded rice field infested with weeds and weeded later by the farmer.

Rodent Management - Wet Seeded Rice

Rodent management: Pre planting phase | Early vegetative – wet-seeded | Late vegetative phase |Reproductive phase | Ripening phase | Postproductive phase

During land preparation and planting of rice crop, rats usually take refuge in vegetation near major irrigation canals, in village gardens and in other non-crop areas which provide good cover. When rats are concentrated in these habitats, it is the best time to organize **community** rat drives. The rat drive can be done until three weeks after planting.

Other important management actions:

- Reduce vegetation along edges of rice fields
- Good hygiene around villages - clean up garbage and keep areas around grain store clear of vegetation, piles of wood, etc.

Insect Management - Wet Seeded Rice

Insect management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

During this phase, rice plants usually compensate for any damage caused by insect pests, especially by defoliators (any chewing insect that feeds on the leaves of plant). Rice plants can develop new leaves after serious injuries by defoliators. Checking the crop for damage allows farmers to determine possible causes.

Important management options to consider are

Water management. Periodic draining and flooding of the field decreases numbers of virus vectors, virus disease infection, and soil-inhabiting insects.
Fertilizer management. High nitrogen application makes rice plants more attractive to insect pests and diseases. Using a leaf color chart helps farmers determine the optimum level of nitrogen required by the crop. Splitting nitrogen application between transplanting and panicle initiation decreases fungal diseases and insects that attack the rice crop. Nitrogen application also favors weed growth. Before nitrogen application, the crop should be weeded first, because any existing weeds will compete with rice for available nutrients.
Weed management. Aside from competing with rice for nourishment, weeds serve as an alternate host of insect pests and pathogens. However, weeds also shelter natural enemies of insect pests. Therefore, although weeds should be removed from inside the field, maintaining some weeds around the outside of the rice field can provide refuge for the natural enemies.
Biological control. Naturally occurring biological control agents such as parasitoids and predators of insect pests can be conserved by minimizing the use of insecticides. Pesticides indiscriminately kill these natural enemies and cause ecological disruptions in natural biological control processes. Insecticide use can promote problems with secondary pests, such as brown planthopper.
Cropping pattern: Synchronous planting vs. asynchronous planting over a given area. Planting at the same time (synchronous planting) is a good way to avoid insect pest damage. Asynchronous planting of nearby fields favors all insect pests. When a field matures, insect pests that developed in that field move to younger adjacent fields, thereby increasing incidence of pest damage.

Planting method:
Direct seeding creates closer spacing between plants, which favors planthoppers—insects that can carry and transmit viruses.

Snail Management - Wet-seeded

Snail management: Early vegetative - transplanted | Early vegetative - wet-seeded

The golden apple snail [*Pomacea canaliculata Lamarck*] 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.

The golden apple snail eats young and emerging rice plants and can completely destroy a crop during crop establishment.

The critical time to control golden apple snail is during the first 10 days for the transplanted crops and the first 21 days for direct wet-seeded crops. After this, the crop growth is typically greater than the rate of snail damage.

The golden apple snail can be managed through biological, cultural, and chemical controls. One biological control is introducing ants that feed on the snail eggs and ducks that eat the young snails.

Cultural control methods include handpicking snails and crushing egg masses, placing leaves that attract snails, good land leveling and field drainage, and constructing canals. Placing toxic plant leaves, building a bamboo screen on the irrigation water inlet and outlet, and planting vigorous seedlings are also ways to manage golden apple snails. Chemical control can also be used at times when other practices fail.

Dry-Seeded Rice

Dry-seeding is sowing of dry seeds into dry or moist, non-puddled soil. This can allow for quicker land preparation and reduces the irrigation water required for crop establishment as “soil puddling” is not required.

With dry seeding, the crop can be established and start growing from the onset of water availability. Dry seeding can increase the effective use of rainfall and reduce irrigation needs. However, dry seeding with subsequent flooding is only possible in clayey soils with low permeability and poor internal drainage.

Crop Establishment

Dry-seeding is sowing of dry seeds into dry or moist, non-puddled soil. This can allow for quicker land preparation and reduces the irrigation water required for crop establishment as “soil puddling” is not required.

Land preparation

The object is to produce a level seedbed with fine soil tilth and free of established weeds. Depending on the available machinery locally, this may be achieved by ploughing at the end of the dry season followed by harrowing or firstly using heavy disc harrows followed by light harrowing, or rotovation with a single axle tractor. Allowing weeds to grow between cultivations may reduce the incidence of weeds in the subsequent crop.

Stale-seedbed. This technique involves repeated plowing and harrowing before planting. Weeds are allowed to emerge and are then killed by cultivation. This technique is effective in reducing the reserve of weed seeds in the soil, and will greatly reduce weed infestation in the subsequent crop.

Cultivating the soil dry

Harrowing to level the soil

Plant population

The target number of plants to be established ranges from 100 to 150 plants per m2. To meet this target, seeding rates vary between 50 and 150 kg per ha depending on the growing conditions and seedbed, seeding method, and quality of the seed.

Sowing methods

Sowing by hand or using fertilizer spreader could be done either by use of a seed drill to place the seed in rows or by broadcasting. Seeds should be placed (not more than 2 cm) covered lightly. Avoid burying the seeds too deep which may cause poor germination.

Broadcast seeded

Seeding in furrows

Emerged seeds of dry-seeded rice before flooding

Weed Management

Weeds should be controlled during the first 30–40 days after sowing or transplanting (DAS/DAT). This is the period where weed competition is greatest and can greatly reduce yield. Crop management and appropriate cultural measures (activities or operations carried out in raising field crops, e.g., land preparation, seed selection, crop establishment, and fertilization) should be done before planting to reduce weed growth in the subsequent crop.

It is important to control weeds in early vegetative growth. A weed free seedbed is important for reducing losses due to weeds.

1. Apply 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. (See the rice knowledge for list of pre-emergence herbicides for dry-seeded rice.).

2. Flood the field from 15 DAS gradually and keep the field flooded (5 cm depth) until 10-15 days before harvest.

3. Remove uncontrolled weed by handweeding before about 21 days after rice emergence.

4. Or, apply 2,4-D at 21-28 DAS if sedges or broadleaf weeds are present, if grass weeds are present apply cyhalofop-butyl when weeds are 5-7 leaf stage or bispyribac sodium 10-15 DAS (Click here to see the list of post-emergence herbicides for dry-seeded rice.)
Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Late Vegetative Phase

From tillering to panicle initiation

The late vegetative phase starts at the tillering stage, which extends from the appearance of the first tiller until the maximum number of tillers is reached. This happens 40 days after sowing (DAS). Stem elongation begins late in the tillering stage and ends just before panicle initiation (52 DAS), which also signals the end of the vegetative phase.

Water Management - Late vegetative phase

Water management: *Pre planting phase* | *Early vegetative – transplanted rice* | *Late vegetative phase* | *Reproductive phase* |*Ripening phase*

Like in the early vegetative stage, continuous ponding of water generally provides the best growth environment for rice and will result in the highest yields. Keep the water level at the field around 5 cm for most plant types. In special problem soils, introducing some form of alternate wetting and drying[AWD; What is AWD?] or increasing the internal drainage rate, may improve crop growth and yield. The underlying reason may be improved soil aeration or the removal of toxic substances.

In case of water scarcity, apply water-saving technologies such as alternate wetting and drying (AWD) , saturated soil culture (SSC), direct dry seeding, or any other technologies as find in the link... [How to manage water scarcity?]

Nutrient Management - Late vegetative

Nutrient management: *Pre planting phase (residue management* | *organic materials and manure management)* | *Early vegetative - transplanted* | *Early vegetative - wet-seeded* | *Late vegetative* | *Reproductive phase* | *Ripening phase*

Rice plants require N during the tillering stage to ensure a sufficient number of panicles. The critical time at active tillering for N application is typically about midway between 14 DAT or 21 DAS and panicle initiation.

Nitrogen (N)

Apply N fertilizer based on the plant's need for supplemental N, as determined by leaf N status. The leaf N status of rice is closely related to photosynthetic rate and biomass production, and it is a sensitive indicator of changes in crop N demand within a growing season. The LCC is a simple and inexpensive tool used to rapidly assess leaf N status and thereby guide the application of N fertilizer to maintain an optimal leaf N content.
Should information be added on how much N to apply as we did in the early vegetative phase?
The standardized IRRI LCC is 12.5 centimeters long, is made of high-quality plastic, and consists of four panels, each displaying a color from yellowish green to dark green. [See site specific nutrient management]

Weed Management - Late vegetative

Weed management: *Pre planting phase* | *Early vegetative - transplanted* | *Early vegetative - wet-seeded* | *Late vegetative* | *Reproductive phase* | *Ripening phase*

Guidelines are the same for both broadcast-seeded and drum-seeded (row-seeded) crops:

- Hand weed at 21–25 DAS.
- When herbicide is an option, choose the most appropriate post-emergence herbicide to control weeds (e.g., for grasses, use cyhalofop-butyl [15 DAS]; for broadleaves and sedges, use 2, 4-D [21–28 DAS]; for a mixture of broadleaves, grasses, and sedges, use bispyribac sodium [20–35 DAS]). See the Rice Knowledge Bank for a list of post-emergence herbicides suitable for direct-seeded rice.

Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Rodent Management - Late vegetative phase

Rodent management: Pre planting phase | Early vegetative – wet-seeded | Late vegetative phase |Reproductive phase | Ripening phase | Postproductive phase

Rats will now have moved from irrigation canals, village gardens, and other non-crop areas into the rice fields, and breeding has just begun. Rodent control by communities will require more labor than earlier because rats are now dispersed throughout the cropping system. However, community rodent control can be effective at this stage.

Insect Management - Late vegetative

Insect management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

Checking the crop for symptoms and damage allows farmers to determine possible causes. The insect management actions available for this phase are the same as those for the early vegetative phase.

Reproductive phase

From panicle initiation to flowering

The reproductive phase begins at panicle initiation and ends at flowering, usually taking 35 days. At this phase, the plant is most sensitive to stresses such as low and high temperatures, and drought. The number of days in the reproductive phase and the ripening phase are the same among most rice varieties.

Water Management - Reproductive phase

Water management: Pre planting phase | Early vegetative – transplanted rice | Late vegetative phase | Reproductive phase |Ripening phase

Lowland rice is extremely sensitive to water shortage at the anthesis/flowering stage, and drought effects occur when soil water contents drop below saturation. Drought at anthesis and flowering results in increase spikelet sterility, decreased percentage filled spikelets, and, therefore, decreased number of grains per panicle and decreased yields. Keep the water level in the fields at 5 cm at all times during this stage.

Nutrient Management - Reproductive phase

Nutrient management: Pre planting phase (residue management | organic materials and manure management) | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

At panicle initiation (about 60 days before harvest of tropical rice), it is critical that the supply of N and K are sufficient to match the needs of the crop. Insufficient N at panicle initiation can result in loss of yield and profit through reduced number of spikelets per panicle. An insufficient K supply at panicle initiation can result in loss of yield and profit through reduced spikelets per panicle and reduced grain filling.

Nitrogen (N)

Apply N fertilizer based on the plant's need for supplemental N, as determined by leaf N status as measured by the LCC. Should information be added on how much N to apply as we did in the early vegetative phase?

Rodent Management - Reproductive phase

Rodent management: Pre planting phase | Early vegetative – wet-seeded | Late vegetative phase | Reproductive phase | Ripening phase | Postproductive phase

Rat control should have been conducted earlier. Rats are now breeding and in the crops. The best control options now are to flood or fumigate rat burrows. Poison is another option, but it MUST be placed in bait stations to reduce access by children and non-target species (e.g., chickens, dogs, native wildlife).

Weed Management - Reproductive phase

Weed management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Weed control is not needed at this stage, however because of the increasing incidence and build-up of weedy rice in rice in Asia, roughing is recommended to remove rice off-types before they mature. Also cutting inflorescence of weeds is suggested to prevent build-up of weeds in the succeeding crops.

Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Weedy rice

Insect Management - Reproductive phase

Insect management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Checking the crop for symptoms and damage allows farmers to determine possible causes. Some management actions during the early vegetative phase—water management, weed management, and biological control—are also applicable at this phase.

Ripening Phase

From flowering to maturing

The ripening phase starts at flowering and ends at maturity. This stage usually takes 30 days. Rainy days or low temperatures may lengthen the ripening phase, while sunny and warm days may shorten it.

Water Management - Ripening phase

Water management: Pre planting phase | Early vegetative – transplanted rice | Late vegetative phase | Reproductive phase | Ripening phase

This period does not necessarily require submersion. Soil that is 80–90% saturated is sufficient. However, for easy of operations, keeping the fields flooded may still be the simplest management approach. Drain the fields some 10-15 days before the expected harvest date to hasten maturity and grain ripening, prevents excessive nitrogen uptake, and make the land better accessible (because it is dryer) for harvest operations.

In case of water scarcity, apply water-saving technologies such as alternate wetting and drying (AWD) , saturated soil culture (SSC), direct dry seeding, or any other technologies as find in the link… [How to manage water scarcity?]

Rodent Management - Ripening phase

Rodent management: Pre planting phase | Early vegetative – wet-seeded | Late vegetative phase |Reproductive phase | Ripening phase | Postproductive phase

Rat control should have been conducted earlier. Rats are now breeding and in the crops. The best control options now are to flood or fumigate rat burrows. Poison is another option, but it MUST be placed in bait stations to reduce access by children and non-target species (e.g., chickens, dogs, native wildlife).

Weed Management - Ripening phase

Weed management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Weeding at this stage is not necessary with regards to prevention of yield loss. However, due to increasing incidence of weedy rice in rice, roughing of rice off-types is needed to prevent weedy rice infestation.
Click here to see descriptions of The Dirty Dozen—the 12 most troublesome weeds of rice in Asia or click here to use the Lucid Weed Key for identification and descriptions of 64 troublesome weeds of rice.

Weedy rice

nsect Management - Ripening phase

Insect management: Pre planting phase | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative| Reproductive phase | Ripening phase

Checking the crop for symptoms and damage allows farmers to determine possible causes. At this phase, the use of biological control agents is the key management option.

Nutrient Management - Ripening phase

Nutrient management: Pre planting phase (residue management | organic materials and manure management) | Early vegetative - transplanted | Early vegetative - wet-seeded | Late vegetative | Reproductive phase | Ripening phase

N absorbed during the ripening phase, in the presence of adequate solar radiation, enhances the grain filling process. Hybrid rice and large-panicle varieties in high-yielding seasons often require N application at early heading. When leaf color, as determined by the LCC, is yellowish green, use only a moderate rate of fertilizer N application (10 to 30 kilograms of N per hectare). When the crop response of large-panicle varieties to fertilizer N is more than or equal to 3 tons per hectare, apply a moderate rate of N fertilizer at early heading regardless of leaf color

Harvesting

The optimal time to harvest a rice crop is when the grain moisture content is between 20 and 25% or when 80–85% of the grains are straw-colored and the grains in the lower part of the panicle are in the hard dough stage. This is about 30 days after flowering. If the crop harvest is too late, many grains are lost through shattering and over-dried grains crack during threshing. Cracked grain will not germinate and will also break during milling. If harvested too early, there will be many immature seed grains and this will reduce quality and yield. The very slender and chalky immature rice kernels will result in excessive amounts of bran and broken grains.

Harvesting operations:

- Cutting
- Threshing

Cutting

The majority of rice in Asia is still cut manually. Mechanical reapers are also being used in some countries but there are problems in cutting crops that have lodged. In larger fields and where human labor is not readily available or has become too expensive, combine harvesters have become more popular. For good results, drain the field 7–10 days before harvesting. When laying the cut crop in the field, make sure that the panicles with the grains stay dry and are off the ground.

Harvesting operations:

Manual cutting

Reaping

Combine

The combine harvester combines all operations: cutting, handling, threshing and cleaning.

Threshing

Threshing should occur immediately after cutting because the longer the cut panicles remain in a stack, the higher the chance of discoloration or yellowing. When the crop is cut manually or with a reaper, it will be threshed either manually or with a mechanical thresher.

Manual threshing

- Use of bare feet or animal to thresh the crop, which is spread on the floor. In some regions, animals are replaced by tractors.
- Separation of grain from the straw by impact through beating the crop against a slatted bamboo, wooden platform, or any other hard object such as a steel oil drum.
- Use of a treadle thresher by holding the crop against a threshing drum driven by a foot crank that combs the grains from the straw.

To loosen the grains from the straw, the crop is often placed in the field for 1–6 days for field drying, a practice that results in a high percentage of broken grain. Field drying should be avoided by all means.

In all manual threshing methods, small straw, chaff, and foreign matter drop with the grains. Therefore, the grain needs to be cleaned.

Manual Threshing

Manual harvesting makes use of traditional threshing tools such as threshing racks, simple treadle threshers and animals for trampling.

Trampling with animals

Rice is manually threshed, then cleaned with a machine thresher.

Treadle Threshing

A reaper cuts and lays the crop in a line. Threshing and cleaning can then be performed manually or by machine.

Post Productive Phase

Postharvest grain losses across all Asian countries have been estimated at 10–15% and, when combined with loss of quality, represent a potential loss in value of between 25 and 50% at market. When a rice crop reaches physiological maturity, it has reached its maximum potential in terms of yield and quality. From that point on, the losses that occur are dependent on how quickly the crop is processed. To maximize their financial return, farmers require a timely harvest, followed by good postharvest technology and management.

Market information

Before any attempt to tackle postharvest problems, a market assessment needs to be undertaken to determine the products and quality grades demanded by the markets and to provide information for better flexibility in seeking markets for improved products and for greater bargaining power. Timely market information can help farmers decide what quality to produce, where to sell, and when to sell.

Quality and quality testing (at harvest and postharvest)

To minimize losses and maximize quality, farmers should have a good understanding of traits that define seed quality, grain quality, and milled rice and of the factors in production and postproduction of rice that have an effect on those quality traits. The IRRI quality kit contains a set of tools that can be used to determine important physical grain quality parameters. It can be used to assess grain and milled rice quality in the field and is ideal for providing training on quality on location. (info on how to obtain the kit).

Cleaning

Threshed seed contains all kinds of trash. This trash can be organic—such as chaff, straw, empty grains and foreign seed—as well as mineral materials such as earth and stones. Seed should be cleaned as soon as possible after harvesting and certainly before drying or storage.

The simple traditional cleaning method is winnowing, which uses wind or a fan to remove the light elements from the grain. Mechanical cleaners that incorporate a fan and several superimposed reciprocating sieves or screens are now used in many countries. These can be manually powered or motorized and have capacities from 100 kg to 2–3 tons per hour. Where combine harvesters are used, there is a trend toward using large-capacity centralized seed cleaners. These are normally equipped with a series of vibrating sieves and are capable of cleaning 10–30 tons per hour.

Types of Cleaning:

Manual Winnowing

Lighter materials such as unfilled grains, chaff, weed seeds, and straw can be removed from the grain by using a blower, air fan, or by wind. Winnowing recovers only the heavier grains.

Paddy Cleaner with sieves and fan

Smaller materials such as weed seeds, soil particles and stones can be removed by sieving the grain through a smaller sized screen

Drying

Rice is usually harvested at grain moisture content (MC) between 24 and 26% (wet basis). Any delays in drying, incomplete drying, or uneven drying will result in qualitative and quantitative losses including discoloration, reduced milling yields, loss of germination, and loss of vigor if grain temperatures exceed 42°C. Insect damage is also more likely at higher MC levels. Grain should therefore be dried to less than 14% moisture immediately after threshing. When seed is to be stored for long periods it should be dried to 12% or less and preferably placed in a sealed container, Table 1.

Storage Period	Required MC for storage	Potential Problems
2-3 weeks	14-18%	Molds, discoloration, respiration loss
8 to 12 months	13 % or less	Insect damage
More than 1 year	9 % or less	Loss of viability

Types of Drying:

- Sun Drying
- Mechanical Drying

Given a typical drying rate of 1% moisture reduction per hour, drying time is usually between 6 and 10 hours. For drying of seed in tropical areas, an air temperature of 40–42 °C is normally used with a heater capable of raising the air temperature 10–15 °C. An air velocity 0.15–0.25 meters per second is required and typical power requirements are 1.5–2.5 kW per ton of paddy (unmilled rice). Stirring the grain in fixed-bed batch dryers halfway through the drying process can reduce moisture gradients in the grain bulk.

Tempering the grain a number of times or in stages during the drying process can help maintain quality. This means drying the grain on a drying pad for a number of hours or in the grain dryer and then tempering the seed by allowing it to cool down for a number of hours in a bin or in the bag. This process should be repeated at least a couple of times until the grain reaches 14% moisture or less.

Another strategy that takes advantage of the drying properties of paddy in order to maximize quality is two-stage drying. In two-stage drying, the surface moisture is removed quickly using very high drying air temperatures using “flash dryers.” At 18% MC, which is safe for temporary storage for 2 weeks, the first-stage drying is stopped and is usually followed by a more gentle second-stage drying—in an in-store dryer to achieve the final MC. Two-stage drying has not taken off in Asia because it needs two different pieces of equipment for one operation.

Grain Storage

If grain is to be stored safely for extended periods, it must

- have less than 13–14% moisture,
- be protected from insects and rodents, and
- be protected from absorbing moisture either through rain or from the surrounding air.

Storage Systems:

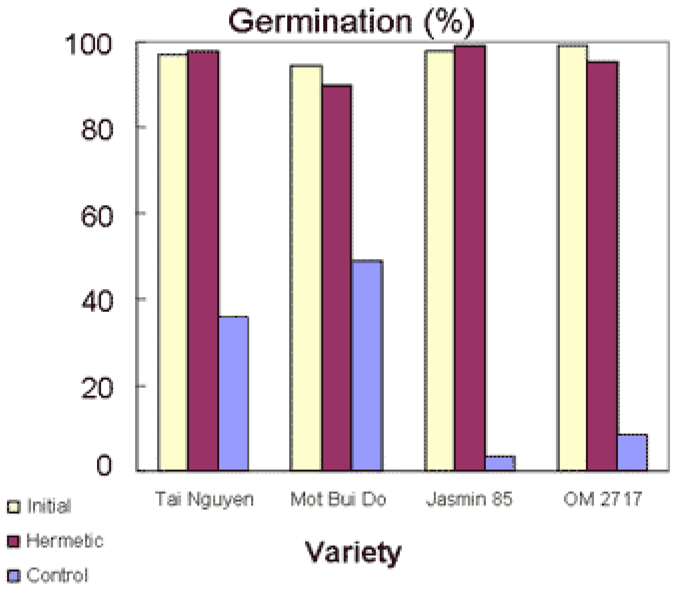
Traditional Storage:

- Granary at Farmer's house in Cambodia
- Traditional Bag Storage
- Silo

Hermetically Sealed Storage Systems:

- Commercial hermetic storage system
- IRRI super bag
- Hermetic storage in plastic containers

Germination rates



Germination rate after 8 months of hermetic storage on germination (red) compared with traditional open storage (blue) for four different varieties, Vietnam, 2005.

Milling

The objective of milling rice is to remove the husk and bran layers and produce an edible, white, high-quality rice kernel. Depending on customer requirements, milled rice should have a minimum of broken kernels, be well polished, and be free from impurities. It is often said that milling is more an art than a science. This is not true. Using good-quality paddy in a well-maintained mill operated by a skilled miller will produce high-quality head rice. Poor-quality paddy will always result in poor-quality milled rice, irrespective of type of rice mill and skills of the miller. Similarly, the use of good milling equipment and good-quality paddy will not ensure a high-quality product if the miller is not properly trained.

Most paddy grains are made up of 20% rice hull or husk, 10% bran or meal, and 70% starchy endosperm (also referred to as total white rice). Total white rice contains both whole and broken grains. Whole grains or head rice should be at least 40–50% of the total milled rice (paddy basis). The byproducts from rice milling are rice hull, rice germ and bran layers, and fine brokens.
A rice milling system can be a simple one- or two-step process or a multistage commercial process. In a single-stage pass mill, husk and bran are removed in one pass and milled or white rice is produced directly out of paddy. This system typically has a capacity of 50–200 kg per hour and is at least efficient inasmuch as milling recovery is only 50–55% and head rice yield is less than 30%.

In a two-stage process, husk and bran are removed separately, and brown rice is produced as an intermediate product. This system usually has a capacity of 0.5–1 tons per hour and is more efficient than a single-pass operation. Milling recovery is more than 60% and there are fewer broken grains.

In multistage milling, rice undergoes a number of different processing steps. Commercial mills use this system. A modern commercial mill in Asia can have 65–70% milling recovery and 50–55% head rice.

Modern rice milling

The best quality milled rice will be attained from a mill that has a system of pre-cleaning the paddy, rubber rollers to remove the husk, two separate whiteners, one polisher, and graders that separate the broken from the whole grain of polished white rice. Having at least two stages in the whitening process and a separate polisher will reduce overheating of rice during milling and allow the miller to set individual machines to give the highest head rice and milling yield. Continuous maintenance, monitoring, adjustment, and replacement of components such as rubber rollers and sieves are essential to maintain production of high-quality rice.

Rodent Management - Post productive phase

Rodent management: Pre planting phase | Early vegetative – wet-seeded | Late vegetative phase |Reproductive phase | Ripening phase | Post productive phase

- Clean up around villages and grain stores.
- If possible, grain stores should be raised off the ground and have rat guards fitted on the wooden supports. (Pictures available.)
- Make sure there are no trees with branches that give easy access to the roof of a grain store.
- A rodent-proof grain store must have NO openings greater than 8 mm (mice) or 14 mm (rats).
- DO NOT use poison in houses and grain stores—use locally made kill-traps instead.

Generally, the rats that invade grain stores and houses are not the same as those living in the rice fields. Therefore, effective rat control in fields may have little effect on rodent damage to stored rice. The exceptions are species of the Rattus rattus complex—in some countries, such as Lao PDR and the Philippines, these animals are pests in both fields and grain stores.