Steps to successful rice production

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IRRI is the world's premier research organization dedicated to reducing poverty and hunger through rice science; improving the health and welfare of rice farmers and consumers; and protecting the rice-growing environment for future generations. Headquartered in the Philippines and with offices in 17 countries, IRRI is a global, independent, nonprofit research and training institute supported by public and private donors.

IRRI breeds and introduces advanced rice varieties that yield more grain and better withstand pests and disease as well as flooding, drought, and other harmful effects of climate change. The Institute develops new and improved methods and technologies that enable farmers to manage their farms profitably and sustainably. IRRI recommends rice varieties and agricultural practices suitable to particular farm conditions and consumer preferences. Finally, IRRI assists national agricultural research and extension systems (NARES) in formulating and implementing national rice sector strategies and programs.

IRRI is a member of the CGIAR consortium and, among global partners, leads the Global Rice Science Partnership (GRiSP), which provides a single strategic plan and unique new partnership platform for impact-oriented rice research for development.

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Steps at a glance

STEPS TO SUCCESSFUL RICE PRODUCTION

Step 1: Use a crop calendar

Using a cropping calendar improves the timeliness and reduces costs

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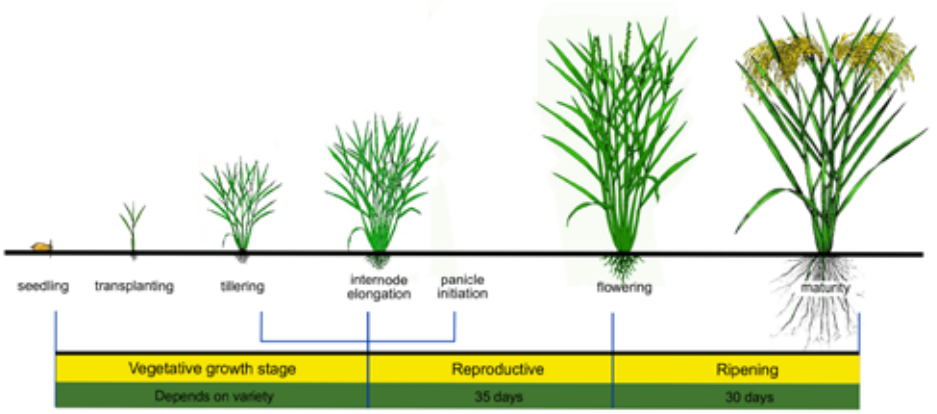
A crop calendar is a picture of your rice growing season: crop production from the fallow, land preparation, crop establishment, and maintenance through harvest and storage. By using a crop calendar, farm activities are better planned, and performed at the right time. It is easier to organize labor and obtain inputs such as seed and fertilizer. Better planning will decrease input costs and increase yields.



How to create a crop calendar

1. Determine the best date to plant.
2. Determine the time the variety takes from planting to harvest (short-duration, 100–120 days; medium duration, 120–140 days; long duration, 160 days or more).
3. Most varieties take 50–55 days from panicle initiation to harvest.
4. Mark on the calendar the date of planting and when each other operation needs to be done (plowing, weeding, fertilizing, and harvesting).
5. Pin the calendar in a prominent place to remind you when things need to be done.

Step 2: Choose the best variety

Select a variety that suits your growing conditions

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The most suitable variety is the one best meeting farmer's and consumer's needs. It may not always give the highest yield and will be influenced by availability of water (either from rain or irrigation), soil type, and field elevation, and whether the rice will be sold or consumed at home.

Varieties should be selected based on good yield potential, resistance to disease, good eating qualities, high milling yield, and are suitable for the market. When selecting a variety check the following:

Crop duration

- Long-duration varieties (160 days and longer) suitable for irrigated areas or flood-prone areas
- Medium-duration varieties (120–140 days) suitable for both rainfed and irrigated areas
- Short-duration varieties (less than 120 days) suitable for drought-prone areas or for double cropping.

Crop height

- Tall varieties (1.4 m and taller) are suitable for flood-prone and unleveled fields, lodging may be a problem.
- Medium height varieties (1–1.2 m) are suitable for most areas and are not as susceptible to lodging when fertilizer is used.
- Short varieties are best suited to level fields especially in irrigated areas. They are responsive to fertilizers and are normally less than 1 m in height.

Grain quality

- A premium is often paid for aromatic varieties, but yields are normally lower.
- Eating quality such as softness, stickiness, and color after cooking are important.

Step 3: Use the best quality seed

Plant pure, clean and healthy seeds

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High-quality seed reduces the required seeding rate and produces strong, healthy seedlings, resulting in a more uniform crop with higher yields.

Good seed is:

- Clean with no stones, soil, or weed seed;
- Pure containing grains of one variety; and
- Healthy having full big grains of the same color with no cracks or spotting.

High-quality seed can be bought as certified seed or produced by the farmer.

Produce high-quality seed

1. Select a level field with well-maintained bunds and easy access.
2. Use clean, pure, and healthy seed.
3. Do a float test on the seed before planting and remove any seeds that float.
4. Use good management practices by planting on time, applying fertilizer, weeding before 21 days after establishment, and not letting weeds go to seed.
5. Rogue the fields by removing all rice plants that clearly look different during the vegetative, flowering, and grain-filling stages.
6. Harvest at full maturity when 80–85% of the grains are straw-colored or at 21–22% moisture.
7. Thresh and dry quickly after harvest.
8. Store seed safely and label containers or bags with variety name and date of harvest.

Step 4: Prepare and level the fields well

Level fields give the best yields

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A well-prepared and leveled field gives a uniform, healthy crop that can compete with weeds, use less water, and give higher yields at a lower cost.

A well-prepared field has:

- Many small soil clods to give good seed-soil contact — clod size and seed size are similar;
- No weeds;
- Harder plowlayer at 10 cm to stop water penetration;
- Level and smooth surface after working; and
- Well-constructed bunds.

To prepare the field

- When possible, plow immediately after the previous harvest — especially if the soil is still moist.
- First or primary plowing. Use a disc or moldboard plow to kill weeds and incorporate crop residue, preferably 6–8 weeks before planting with maximum depth of 10 cm.
- Second plowing. Plow across the field with the disc or tine harrow at least twice to make small clod sizes. Second plowing should be 2–3 weeks before planting and the last harrowing 1 week before planting with maximum depth of 5–7.5 cm.
- Repair bunds, destroy rat burrows, repair any holes and cracks, and re-compact the bunds. Bunds should be at least 0.5 m high and 1 m wide.
- Leveling the field will give better water coverage, better crop establishment, and better weed control.
- Soil puddling should be done at least 1–2 days before seeding to allow the water to clear when direct seeding.

Step 5: Plant on time

Plant on time for higher yields

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Planting the crop on time will help produce a fast-growing, uniform crop that will have higher yields and will be better able to compete with weeds and pests. The best time to plant depends on the locality, variety, water availability, and the best harvest time. Rice can either be transplanted from a nursery or direct-seeded in the field. Transplanted crops will normally take less time in the production field but 10–15 days longer for the total crop duration. In both cases, a well prepared seedbed is needed.

For transplanted crops:

1. Select a nursery site that is 1/10 in size of the intended planting area.
2. Prepare the nursery by plowing at least twice and harrow at least once.
3. Level the soil surface and put in drainage lines across the field.
4. Pre-germination and sowing. Soak the seed for 24 hours and then drain for 24 hours in the shade. Broadcast seed in the nursery evenly, over the water-covered soil surface.
5. Apply seed: 30–40 kg seed/ha transplanted area.
6. Apply both chemical and organic fertilizer in the field before the last plowing.
7. Transplanting age: short-medium duration varieties need 20-30 days and long-duration varieties need 20-40 days in nursery after seeding.
8. Transplant in lines into puddled and water-covered fields.
9. Maintain water coverage in field

For direct seeding:

1. Prepare the field by plowing at least twice and harrowing once-compare seed size and clod size.
2. Level the soil surface.
3. Apply and incorporate basal fertilizer before the last plowing or at 10 days after establishment.

Wet direct seeding:

1. Pre-germination of seed. Soak the seed for 24 hours and then drain for 24 hours in the shade before broadcasting evenly over the water-covered soil surface.
2. Broadcast pre-germinated seed at 100 kg/ha
3. Allow surface water to drain or percolate naturally into soil
4. Keep soil surface moist by adding water
5. Add permanent water at 10–15 days after establishment or at 2–3-leaf stage.
6. Apply basal fertilizer after permanent water is added.

Dry direct seeding

1. Hand broadcast dry seed at 100 kg/ha or machine drill seed at 80 kg/ha and 20 mm depth
2. Apply basal fertilizer through the seed drill
3. Cover broadcast seed and fertilizer with a light harrowing
4. Flash flood until 15 days after emergence or 2-leaf stage then add permanent water.

Step 6: Weed early

One year's seeding equals
seven years weeding

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Weeds compete directly with the rice plants and reduce rice yield. Each 1 kg dry matter of weeds is equivalent to 1 kg grain loss. Weeds cause most yield loss within the first 20–50 days after crop establishment. Weeding after panicle initiation may also be important to prevent weeds shedding seeds in future crops.

Effective weed management

- Plowing and harrowing in fallow should be undertaken at least 10–14 days apart or after rain.
- Good land leveling reduces weed growth because most weeds have trouble germinating under water.
- Select varieties which have early vigor.
- Use clean rice seed which is free of weed seeds.
- Apply permanent water early — weeds cannot germinate under water.
- First weeding begins within 2–3 weeks after establishment and the second in another 2–3 weeks. Weed before fertilizer application.
- Using herbicides. Identify the weed correctly and use the appropriate herbicide as recommended on the label.
- Spray when the weeds are small.
- Apply pre-emergence herbicides after planting prior to establishment.
- Apply post-emergence herbicides after emergence being careful of crop damage.
- Herbicides are poisonous; if they are not used properly they can cause health and environment problems. Label them clearly and keep them out of children's reach.
- Always use protective clothing when spraying.
- Do not wear raincoats when spraying as this increases sweating.

Step 7: Fertilize to maximize returns

Balanced use of fertilizer nutrients
gives the best returns

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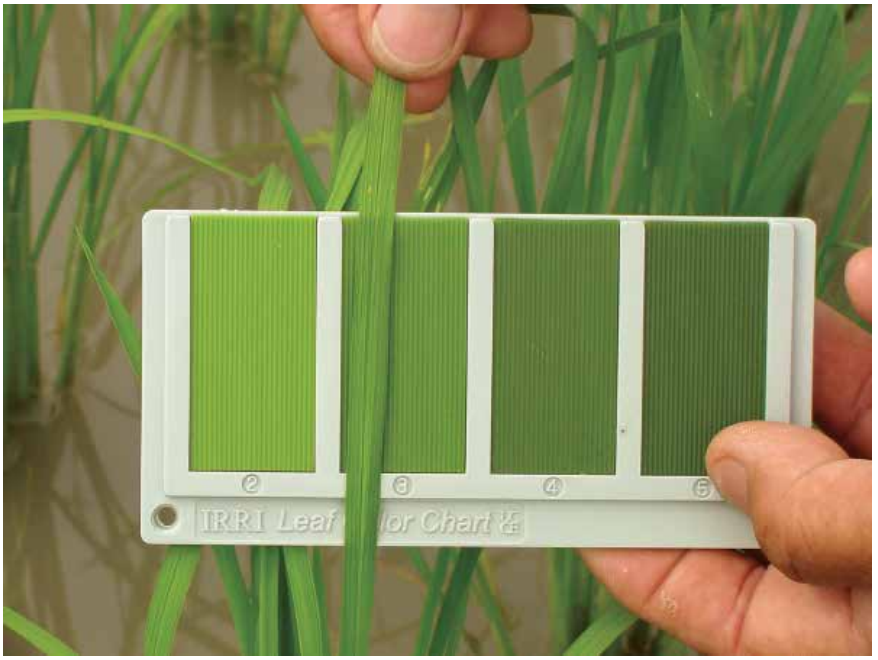
Most soils provide only limited amount of nutrients to the crop, therefore fertilizers need to be applied to increase grain yield. In some cases, fertilizers are also added to improve the soil's physical condition. The amount and type of fertilizer applied are determined on the assumption that 1 ton of grain will remove 15 kg nitrogen (N), 2–3 kg phosphorus (P), and 15–20 kg potassium (K). These base rates need to be modified according to the soil type, the season, the crop condition, prevailing weather conditions, and efficiency of application. For efficient fertilizer use:

- Use organic fertilizer (manure, compost, straw, husk, plant leaves) whenever possible, especially in nurseries.
- Apply fertilizer according to soil type and expected yield. As a guide, a 2 t/ha yield on clay loam soil will require 20 kg N and 5 kg P. Sandy soils may require another 10–15 kg K. Double these recommendations for a 3 t/ha expected yield.
- Apply all P, K, and 10% N evenly and incorporate just before seeding or transplanting. For direct seeded broadcast crops, it is okay to apply 10–14 days after establishment when there is water in the field.
- Apply remaining N (urea) in 2 equal portions at 30 days and 50–60 days (panicle initiation) after emergence.
- In established crops, apply chemical fertilizer only in standing water and evenly across the whole field.
- Do not apply high rates of fertilizer for traditional varieties as they may have limited response and cause lodging.
- Do not use chemical fertilizer if you need more than 5 kg paddy to pay for 1 kg of fertilizer.
- Inorganic fertilizers must be stored in a dry and cool place that is out of children's reach.



Step 8: Use water efficiently

Crops cannot grow without
good quality water

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Water availability largely determines the potential crop yield. For a crop to continue to grow, the water supply needs to be similar or a little above evaporation. In an efficient system, each 1 kg of grain produced will require a minimum of 2,000 liters or 2 m^3 of water. Good water control increases crop yields and grain quality as well as improving the efficiency of other inputs such as fertilizer, herbicide, and pesticides. To maximize water-use efficiency:

- Maintain the bunds;
- Level the fields;
- Puddle the fields where possible;
- Use direct-seeding techniques;
- Use short-duration crops; and
- Harvest on time.

Water quality

Good-quality water is necessary to maximize crop growth. The rice plant is susceptible to salinity especially at the seedling stage and during the panicle development stage from panicle initiation to booting. Symptoms of salt toxicity include "firing" of leaves and reduced dry matter production. The effects of high salinity during panicle development are less obvious as there is little leaf effect, but florets and grain numbers per panicle are reduced greatly reducing yield.

Factor	Units	No problem	Slight –moderate problem	Severe problems
pH	no units	6.5–8.5	<6.5;>8.5	<6.5;>8.5
Salinity (water) – EC_w	dS/m = mmol/cm	<2.0	2.0–2.6	>2.6
Salinity (soil) – EC_s	dS/m	<3.0	3.0–3.8	>3.8
TDS	mg/l	<450	450–2,000	>2,000
Specific ion toxicity				
Sodium – SAR	no units	<3	9	>9
Chloride	me/l	<4	10	>10
Boron	mg/l	<0.7	0.7–3.0	>3.0
Bicarbonate HCO_3^{2-}	me/l	<4	>4	>4

Step 9: Control pests and diseases effectively

Prevention is the best pest and diseases control

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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. The best control for pests and disease problems is prevention. To limit pest and disease incidences in a rice crop, the following recommendations can be followed:

1. Practice good cleaning of equipment.
2. Clean the field between seasons by managing stubbles and ratoons, and by maintaining & repairing bunds.
3. Use clean seeds and resistant varieties.
    - Certified seed is recommended. If certified seed is not available, use clean seed having no discolored seeds, weed seeds or other rice varieties mixed in.
    - Use short-duration and resistant cultivars to decrease insect pest populations.
4. Plant at the same time as your neighbors (or within a 2 week window) to minimize insect, disease, bird, and rat pressure on individual fields.
5. Do not over apply fertilizer. Following specific fertilizer recommendations is important because high nitrogen can increase susceptibility to certain pests and diseases.
6. Encourage natural pest enemies.
    - Overuse of pesticide is common among farmers and can actually lead to pest outbreaks.
    - Natural enemies of rice pests are killed when pesticides are applied which can lead to a pest outbreak.
7. Do not apply pesticide within 40 days of planting.
    - Rice crops can recover from early damage without affecting yield.
    - Get appropriate information on specific diseases that require early management.

If there are pest or disease incidences in the crop, it is important to diagnose the problem accurately. For help with the diagnosis, seek advice from a professional. You may seek advice through *Rice Doctor,* a diagnostic app to assist in identifying pests and diseases. (http://ricedoctor.irri.org).

When deciding to use a chemical for pest and disease control, it is important to:

- Use well-maintained spray equipment that has been properly calibrated;
- Apply the dosage recommended by the manufacturer; and
- Follow the safety precautions for mixing and spray applications.

Step 10: Harvest on time

Protect your harvest – thresh and dry quickly after cutting

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Harvesting the crop on time is very important to maximize yields and grain quality. Crops harvested too early will have many unfilled and immature grains. Immature grains break easily when milled and will not germinate when used for seed. If crops are harvested late, heavy losses will occur through shattering and bird attacks. Quality will also decrease due to grain weathering, resulting in breakage and downgrading due to undesirable grain color.

Crops should be harvested when:

- Grain moisture is between 20–22%, which is normally about 30 days after flowering;
- 80–85% of the grains are straw-colored;
- Grains in the lower part of the panicle are hard, not soft; and
- Grains are firm but not easily broken when squeezed between the teeth.

After cutting, maximize grain quality by:

- Ensuring the panicles do not touch the ground or lay in water;
- Minimizing the time the cut panicles remain in large bundles in the field — thresh within 24 hours of cutting;
- Drying the grains as soon as possible after threshing;
- Turning or stirring the grains at least once every hour when sun drying to achieve uniform drying;
- Sun drying on tarpaulins or clean drying pads;
- Keeping the thickness of the grain layer at 3–5 cm;
- Covering the grain on hot days during mid-day to prevent over-heating, and covering immediately if it starts raining;
- Cleaning the grain by repeated winnowing after drying; and
- Storing the rice in a cool, dry, and clean area — preferably in sealed containers for seed.

Step 11: Store safely

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Rice is best stored as paddy because the husk provides some protection against insects and helps prevent grain quality deterioration. A safe storage system will prevent the grain from getting wet after drying and also give protection from insects, rodents, and birds.

Rice can be stored for longer periods if:

- Moisture content is maintained at less than 14% for grain and 12% for seed;
- Grain is protected from insects, rodents, and birds; and
- Grain is protected from re-wetting by rain or from the surrounding air.

A rule of thumb for seed is that the life of the seed will be halved for every 1% increase in moisture content or a 5°C increase in storage temperature above recommended levels.

Rice storage systems

Bag storage system

- Bags should not be stacked higher than 4 meters.
- Bags should be stacked under a roof, in a shed or under water-proof tarpaulins.
- A one-meter gap should be left between and around stacks.
- Bags should be stacked on pallets or above ground.
- Bags should be stacked so that fumigation can be undertaken if necessary.

Bulk storage

Grain can be stored in bulk in containers made from wood, metal, or concrete and located under or inside the house. While these storage containers vary in size, they all need to be protected from insect, rodent, and bird attacks as well as moisture uptake.

Hermetic or sealed storage

Sealed or hermetic storage systems are an effective means of controlling grain moisture content and insect activity for seed or grain stored in tropical regions. Sealed storage containers come in all shapes and sizes ranging from 50 kg-Super bags, small 25-liter plastic containers, and 200-liter oil drums to costly sealed large plastic commercial storage units of 1–300 tons.

Step 12: Mill efficiently

Poor grain quality into the mill means poor quality rice out

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Milling rice paddy removes the husk and bran layer to produce white rice. Rice is best milled at 13–14% moisture content. Best results are attained when the process is completed in a number of stages. Grain temperatures should not exceed 45°C during the process. An efficient mill removes the husk (20%), the bran or meal (8–10%), and leaves 70% as white rice. Rice grown in irrigated systems should attain 60% white rice as head rice (unbroken, white kernels) and rain fed systems 40–50% as head rice. Rice is milled in several ways.

1. Hand pounding using a mortar with a pestle results in very high numbers of broken rice and leaves brown rice (meal layer still attached). Cleaning of the husk is done by winnowing.
2. A one-step milling process where the husk and the bran are removed in one pass and white rice is produced directly from the paddy. The single-pass rice mill is an adaptation of the Engleberg coffee huller. This process results in many broken kernels, low white rice recovery (50–55%), and head rice yields less than 30%. The fine brokens are often mixed in with the bran and the ground rice husk.
3. A two-step milling process where the husk and the bran are removed separately. These mills are often called compact rice mills and, in many countries, have superseded the Engleberg mill. The two-stage mill has separate hulling and polishing processes. Rubber rollers remove the husk and the brown rice is polished with a steel friction whitener. These mills have a capacity of 0.5–1 t/hour paddy input and are often used for custom milling in rural areas. The milling performance of the compact rice mill is superior to the single-pass huller with milling recoveries normally above 60%.
4. A multi-stage milling process where rice passes through a number of different operations. The milling process in larger commercial mills combines a number of operations and produces higher quality and higher yields of white rice from paddy rice. The process involves:
    - Pre-cleaning the paddy prior to milling;
    - Removing the husk or outer layer from the paddy;
    - Polishing the brown rice to remove the bran layer;
    - Separating the broken grains from the whole kernels;
    - Bagging the milled rice; and
    - Managing the by-products.

Step 13: Understand the market

Eating quality is determined by the consumers

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The value of milled rice in the market is determined by a number of physical and chemical characteristics, and the consumers, which will vary within and between countries.

Physical characteristics

Milling degree or color. The degree of milling or amount of the brown rice removed affects the color of white rice and often the price. Under-milled rice absorbs water poorly, does not cook well, and is normally cheaper.

Head rice percentage or % broken. Head rice (whole kernels) also includes broken kernels that are 75–80% of the whole kernel. High head rice yield is one of the most important criteria for measuring milled rice quality. High-quality rice normally has less than 5% brokens.

Whiteness or translucency. This characteristic is a combination of varietal physical characteristics and the degree of milling. During milling, the whitening and polishing process greatly affects the whiteness of the grain and its transparency

Chalkiness. Grain appearance is affected by the amount of chalkiness or white belly. Chalkiness is caused by interruption of the final grain filling. Though chalkiness disappears upon cooking (and has no direct effect on cooking and eating qualities), excessive chalkiness often downgrades the quality and reduces milling recovery.

Chemical characteristics

Gelatinization temperature or cooking time. Environmental conditions such as temperature during ripening influence gelatinization temperature. There is normally a preference for rice with intermediate gelatinization temperature.

Amylose content or stickiness. The amylose content of rice usually ranges from 15–35%. High-amylose rice has high volume expansion, grains cook dry, are less tender, and become hard upon cooling. Low-amylose rice cooks moist and sticky. Intermediate-amylose rice (21–24%) is preferred in most rice-growing areas of the world.

Gel consistency measures the tendency of the cooked rice to harden on cooling. Varieties with a softer gel consistency are preferred if rice is to be consumed after cooling or if cooked rice with higher degree of tenderness is desired.

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