

Package of Practices for Black Rice

Background

Black rice belongs to *Oryza sativa* L., the same species as white rice and red rice. It is often referred to as "Forbidden Rice" or "Emperor's Rice," has an uncertain origin but is known to have originated in Asian countries such as China, India, Japan, and Vietnam. Historically, it was reserved exclusively for emperors and royal families in ancient China, with severe consequences for unauthorized consumption. Also called "Purple Rice" due to its deep purple-black hue, this rice holds both cultural and nutritional significance. Although black rice has traditionally been cultivated by locals along Bhutan's borders with India, its current production is limited to small pockets within the country. Black rice can be produced in the following two agro-ecosystems:

- The medium altitude zone of valleys and foothills (800-1600 masl) with dry sub-tropical and humid sub-tropical climate, which accounts for 45 % of the total rice area, for instance, Wangdue-Punakha valley, Tsirang and Dagana.
- The low altitude zone (600-800 masl) with wet sub-tropical climate, which accounts for 35 % of the total rice area, for example, Samtse and Sarpang.

Climate

Black rice is a crop of tropical climate. However, it is also grown successfully in humid to sub-humid regions under subtropical climate. Rice requires fairly high temperature, ranging from 20° to 37°C. The optimum temperature of 30°C during day time and 20°C during night time is more favorable for the development and growth of rice.

Soil

Rice can be grown under diverse soil conditions. Soils having good water retention capacity with good amount of clay and organic matter are ideal for rice cultivation. Clay or clay loams are most suited for rice. Such soils are capable of holding water for long and sustain the crop. Rice plant can tolerate wide range of soil reactions, but it has a preference for slightly acidic soils. It grows well in soils having a pH range between 5.5 and 6.

Field preparation

Land or field preparation is one of the important factors that influences rice yields. It provides good physical, chemical, and biological conditions of the soil for optimum plant growth. Benefits of proper land preparation include:

- Water management: It is easier to manage water in the field where land preparation is properly done. Rice fields build a 'plough pan' from subsequent tilling operations which help to retain water in the field.
- Weed management: Land preparation is a good way of weed management. Tillage or ploughing considerably reduces weeds by killing germinating seeds.
- Land levelling: Field levelling is a key aim in land preparation which helps in water management, thereby controlling many weed species.
- Residue breakdown: Crop residues and weeds are broken down during land preparation which aids in decomposition of organic matter and adds fertility.

Steps for field preparation

- Pre-irrigate the field, if it is dry, before ploughing.
- Plough the field 20-25 cm deep using bullock-drawn implements, power tiller or tractor depending on land terrain and available farm resources. Ploughing exposes eggs of harmful insects, pests and seeds and rhizomes of weeds.
- Dig the corners of the field manually where the plough may not have reached. Also, get rid of the weeds and grasses from the bunds and walls which may later harbour rodents. Bunds should also be repaired for impounding water in the field.
- Flood the field thereafter and keep flooded or saturated for a few days. This will help in decomposition of crop and weed residues.
- Drain the water slightly and puddle the field using a rotovator or other implements as needed to break clods and ensure a fine soil tilth. Ideally, puddling should be done about two weeks before the date of transplanting. Puddling is an important operation for transplanted rice to create ideal growing conditions.
- Repair and maintenance of bunds and the incorporation of chemical fertilizers, if any, should be done before the final puddling.
- Level the field prior to transplanting using a mechanical leveller or wooden leveller. Land levelling improves water management which improves weed suppression and control, crop establishment, nutrient use efficiency, crop uniformity and maturation, drainage and ultimately rice yields.

Seed rate and sowing time

The optimum seed rate for rice in raising seedlings is 20-24 kg per acre (or 50-60 kg per ha) depending on the seed quality. Seed selection can be done using saline water. Put seeds in a bucket of saline water, stir the seeds and discard seeds that float on the surface.

Refer the following guide for nursery sowing in different areas:

- Mid altitudes (800-1600 masl) : May to mid-June
- Low altitudes (below 800 masl) : Whole of June

Nursery management

Following are recommended methods for more efficient seedling production, depending on altitude, temperature and water availability.

- i. Semi-dry bed method
- ii. Wet bed method
- iii. Tray method
- iv. Poly tunnel method
- v. Dapog method

Transplanting

Transplanting can be done manually or using a mechanical rice transplanter. Seedlings need to be raised in trays for machine transplanting.

Methods of transplanting

- Rice can be transplanted at random or in straight rows or lines. In Bhutan, random transplanting is the most common method, which requires less labour compared to planting in lines.
- Traditional or random method of transplanting can be adopted if the weed pressure is expected to be low, if herbicide such as Butachlor is intended to be used for weed control and where rice terraces are narrow and small.
- Avoid wide spacing in random transplanting. A plant density of 25-35 hills per square meters is optimum.
- Line planting is recommended where the aim is to control weeds using a rotary weeder. Line planting also enhances the attainment of an optimum plant population and facilitates weeding and other operations.
- Maintain row spacing of 20 cm and plant to plant spacing of 15-20 cm within the rows. Transplant 2-3 seedlings per hill at a depth of 2-3 cm.
- Increase the number of seedlings per hill if transplanting is delayed or if the seedlings are old to compensate for reduced tillering.
- There is no single spacing recommended for all varieties – it will depend on the variety, soil fertility and planting season.
- If a rice trans-planter is used, allow the mud to settle for a day before transplanting to avoid sinking of seedlings. Land preparation has to be thorough and seedlings need to be raised in trays.

Time of transplanting

The time of rice transplanting depends on the altitude and also the variety. Use the following guide for different rice growing zones.

- Mid altitudes (800-1600 masl): June to July
- Low altitude (< 800 masl): July to early August

Weed management

Weeds are the worst competitors of rice plant. They compete for water, nutrients, sunlight and other growth requirements and hence reduces grain yields.

Recommendations

- Where weed pressure is expected to be low or moderate, 2 hand weeding at 20 and 40 days after transplanting are sufficient. It needs to be stressed that if hand weeding is to be done, plants should be close spaced and the first weeding performed not later than 30 days after transplanting.
- Concentrate on the use of line planting and rotary weeding where weed pressure is expected to be high. Two rotary weedings 20 and 40 days after planting are recommended.
- Where grass and sedge weeds are expected to be severe, Butachlor will be very effective. It should be applied at the rate of 10 -16 kg of 5 % granule "Punch" per acre 3- 6 days after transplanting.
- Indirect or complementary weed control methods like good land preparation, proper water management, use of weed-free seedbeds and seeds should be emphasised.

Nutrient management

Rice requires a balanced supply of nutrients, water, air and sunlight to grow well. Nutrients can come from either organic or inorganic sources. Organic sources include biological nitrogen fixation sources such as green manures and blue green algae, compost and animal manures. Nutrient composition varies with the sources. Green manures such as *Sesbania aculeata* can accumulate 80–100 kg N/ha in 45–60 days of growth. The advantage of organic sources of nutrients is that they can provide a wide range of nutrients, whereas inorganic fertilizers only produce a single or few nutrients. Organic sources also provide "bulk" matters that are important for soil organic matter. Soil fertility status is subject to change from one location to another and from one cropping season to the next. Ideally, analysis of soil would determine the nutrient requirements of a specific field but may not be possible all the time.

Fertilizer recommendations

Based on the field experiments done by NSSC and present knowledge, the following fertilizer recommendations for rice are made:

- For local rice varieties like Black rice, the general recommended rate is **30-20-8 kg NPK per acre**.
- However, fertilizer doses should be determined based on soil analysis results. NSSC provides free soil analysis services for farmers.
- Apply the entire dose of P and K as basal dressing during land preparation. If half the N is applied basally, top dress the remaining half at active tillering stage (20-35 days after transplanting) or after first hand weeding. Further splitting of N into equal doses at tillering and PI stage can improve rice yields.
- To improve soil structure and water retention capacity, use FYM or compost prior to or during land preparation. Generally, 2-3 tons of FYM per acre is recommended. Supplementing with N topdressing @ 14 kg per acre after 30-40 days of transplanting can lead to higher yields.
- Wherever possible, use green manures like *Sesbania aculeata* (Dhaincha) as a pre-rice manure. Sow dhaincha in April-May @ 20-25 kg/acre and incorporate in the soil after 6-8 weeks. Transplant rice after about 2 weeks of incorporation.

Water management

Water is a critical input for rice production. However, it is becoming increasingly scarce and expensive and it is important to find methods to reduce water consumption without compromising yields. Unlike the conventional thinking of our farmers, it is not necessary to keep the rice fields flooded all the time for higher yields. Recent research has shown that water use can be greatly reduced without affecting grain yield. Keeping rice fields moist or in field capacity saturation without standing water saves water. However, if the soil drops below field capacity saturation, yield potential can be reduced and weeds can compete more freely.

Irrigation methods

There are generally three types of irrigation and water management practices commonly followed, depending on water availability:

Continuous flooding with standing water: there is continuous water in the field at varying depths of 3-8 cm. It is practiced where there is abundant and assured irrigation water.

Plant protection

Integrated management is recommended to manage pest and diseases which will minimize crop losses. The management should start from nursery till crop harvest. Constant field monitoring and surveillance is important for disease and pest management which will also help to determine the requirement of control measures. Integrated management includes good cultural practice and use of resistant varieties. Disease pathogens are mostly viruses, bacteria and fungi that are parasitic and live in or on rice plants which limit yield and affect grain quality. Their development depends on environmental factors such as temperature, humidity and light. Common diseases in the country and their management are described below.

Rice Blast (*Pyricularia oryzae* or *Magnaporthe grisea*)

Blast is one of the most important diseases of rice and it attacks all aboveground parts of the rice plant at any growth stages. In Bhutan leaf, node, neck and panicle blast are common. *Echinochloa* species are alternate host for blast.

Symptoms

- Leaf blast - the lesions are elliptical or spindle shaped with brown borders and white centres which enlarge and eventually kill the leaves [Pic (a) and (b)].
- Collar blast - pathogen infects the collar that can kill the entire leaf blade [Pic (c)]
- Node blast - node turns blackish and breaks easily [Pic (d)].
- Blast on the neck of the panicle - greyish brown lesion on the neck and the panicles break when severe [Pic (e)].
- No grain formation if disease occurs during flowering stage
- Brown lesions - on the branches of panicles and on the spikelets.

Favourable factors

- Cloudy and overcast skies, frequent rain, and drizzles favor the development of rice blast.
- Relative humidity of 90 % or higher and long duration of leaf wetness favours development of blast disease.
- The optimum temperature required for spores to germinate is 25-28°C.
- Excess amount of nitrogen fertilizer is conducive for blast development.

Cultural management

- Planting resistant varieties
- Proper management and sanitation of the field
- Proper crop residue management after the harvest
- Do not apply over dose of nitrogen fertilizer as it enhances the development of blast disease
- Apply balance dose of fertilizer
- Soak seeds in hot water at 55°C for 1 hour.

Chemical

- Treat seed with solution of *Tricyclazole* @ 3g/1kg seed
- Spray *Tricyclazole* @ 1gm/1lit of water 1-2 times depending on the environmental condition. Use stickers like mustard oil or sandovit to prevent washing away of the chemicals due to rainfall.

Brown spot (*Helminthosporium oryzae*)

Brown spot is one of the common diseases of rice in poorer soils. Disease occurs both in the nursery and transplanted field. Infected seeds lower the grain quality and cause yield loss.

Symptom

- Fungus produces small, circular to oval, dark brown or purplish brown lesions about the size and shape of sesame seed. Sometimes the symptoms are similar to blast lesions in certain rice varieties
- Fully developed spots are brown with gray or whitish centers surrounded by a reddish-brown margin
- Infected seedlings are stunted or killed
- Infected panicles are with brown spots
- It can infect roots and causes a black discoloration
- It may infect the glumes and grain causing dark brown to black oval spots causing a black discoloration.

Favourable factors

- High relative humidity (86-100 %), cloudy weather, and continuous temperature of 16-36°C
- Use of infected seeds, volunteer rice and rice debris
- The disease is common in nutrient-deficient soils and water stressed soil but rare on rice grown on fertile soils.

Cultural management

- Presoak seed before planting in cold water for 8 hours
- Hot water seed treatment (53-54°C) for 10-12 minutes is effective before sowing
- Proper management of straw and rice debris by burning or removing from the field
- Use resistant varieties
- Proper management of fertilizer by using silicon fertilizers (use e.g.- calcium silicate slag).

Chemical

- Seed treatment with captan, thiram, carbendazim, or mancozeb.
- If severe, spraying of mancozeb and tricyclazole at tillering and late booting stages.

Sheath blight (*Rhizoctonia solani*)

Symptom

- Irregular large spots on leaf sheath
- Small ovoid, water-soaked greenish-gray lesion near the water line
- Older lesions - elliptical or ovoid with a grayish white center and light brown to dark brown margin
- Severely infected plants produce poorly filled or empty grains, especially those on the lower portion of the panicles
- Rotting on the leaf sheath enclosing the young panicles.
- In cases of severe infection, the panicle may fail to emerge completely
- Panicles rot, and florets turn red-brown to dark brown and grains become sterile, shrivelled, partially or unfilled and discolored
- Whitish powdery growth may be found inside affected sheaths.

Favourable factors

- High Relative humidity and temperature (28-32°C) with high leaf wetness favours development of the disease.
- High nitrogen fertilizer
- Disease is soil borne and the pathogen can be spread through irrigation water along with soil and infected crop residues.

Cultural management

- Optimized Seeding rate or plant spacing to avoid closer plant spacing or dense crop growth
- Maintaining field sanitation by removing weeds, infected stubbles or crop residues

Chemical

- When severe, spray fungicides such as Carbendazim @ 0.5 g/lit of water.

Stem Borer (*Scirpophaga incertula*)

There are different types of stem borer such as white, yellow, purple, striped and dark-headed. These insects attack rice plants at tillering and ripening stages causing dead-hearts and white heads respectively.

Damage symptoms

- Cutting and drying of the central tiller during the vegetative stage (dead heart)
- Bore into the stem at reproductive stage leading to unfilled panicles (white head) which can be easily pulled from the base.

Favourable factors

- High nitrogen favours population build-up of the stem borers
- Infested stubbles that remain in the field act as source of infestation.

Cultural management

- Early planting avoids infestation
- Ploughing and flooding the field will control eggs, larvae and pupae from developing
- Harvest crop at ground level to remove the larva in stubble
- Grasshoppers, ants, birds and toads feed on the pest
- Pheromone traps will, attract the stem borer which can be collected and destroyed to reduce the population in next season.

Chemical

- When severe (10 % hills affected or 1 panicle/hill) or (4 egg masses/hill) spray insecticide such as Dimethoate 30 EC @ 1ml/ 1lit of water.

Rice Case worm (*Nymphula depunctalis*)

Rice case worm is found in irrigated and rainfed rice with standing water. The larvae are semi-aquatic which stay inside the case built from cutting of rice leaves. During severe cases it causes patches of defoliation resulting in stunted growth and death of plant.

Damage symptoms

- Cutting off leaf tips to make leaf cases
- Field looks whitish due to leaves scrapping
- Leaves look as if cut with a pair of scissors
- Older larvae are enclosed within the case and feed by scraping leaf tissues or biting through leaf sheaths
- Leaf cases can be found floating on water

Favourable factors

- rice field with standing water
- transplanting young seedlings also favours pest infestation

Cultural management

- Avoid overcrowding and maintain wider spacing during transplanting
- Maintain proper drainage
- Cases can be destroyed by moving a rope or long stick-on crop and collecting and destroying the larvae
- Spiders, dragonflies, and birds eat the adults.

Chemical

- When severe (>25% leaves damaged or 10 leaves/hill) spray insecticides such as Chlorpyrifos 20 EC @ 4ml/ 1lit of water.

Rice Leaf Folder (*Cnaphalocrocis medinalis*)

Leaf folders are common in the wet sub-tropical rice ecozone. There are three species of leaf folders. It infests at early crop stages and their damage does not cause significant yield loss. Crop generally recovers from this damage.

Damage symptoms

- Folds the leaves and stitch the leaves sides ways
- Translucent larvae remain inside the leaf fold and feed on green matter
- Distortion and whitening/yellowing of margins of young leaves
- Faecal matter present.

Favourable factors

- heavily fertilized fields
- high humidity and shady areas
- Presence of grassy weeds from rice fields and surrounding borders.

Cultural management

- Drain and dry field
- Flood and plough field after harvesting if possible
- Remove grassy weeds from fields and borders
- Reduce density of planting and use balanced fertilizer.

Chemical

- When severe (>25% leaves damaged or 10 leaves/hill) spray insecticide such as Chlorpyrifos 20 EC @ 4ml/ 1lit of water.

Army Worm (*Mythimna separata*)

Army worms occur mainly in the southern belt. Out breaks depend on periods of long dry spells during the rainy seasons. They can damage crops from seedling to grain ripening stages.

Damage symptoms

- Cutting off leaf tips, leaf margins, leaves and even the plants at the base
- Cutting off rice panicles from the base.

Favorable factors

- Periods of drought followed by heavy rains.

Cultural management

- Do not allow the field to be dry
- Grasshoppers, ants, birds and toads feed on the pest.

Chemical

- When severe (two damaged leaves/ m²) spray insecticide such as Malathion 50EC @ 2ml/ 1lit of water.

Rice Bug (*Leptocorisa acuta*)

Rice bugs infestation occurs during reproductive stages of plant development. It is one of the major pests in Bhutan. Slender and brown-green nymphs and adults feed on endosperm of rice grains during milky stage which causes empty grains.

Damage symptoms

- Feeding causes deformed or spotty grains at the soft or hard dough stage
- An odour is often emitted indicating their presence
- Feeding causes empty or small grains during the milking stage
- Grains become dark, deformed or spotty and erect panicles.

Favourable Factors

- Warm weather, overcast skies, and frequent drizzles presence of alternate hosts
- Weeds in and near the field.

Cultural management

- Grasshoppers, ants, birds and toads feed on the pest.
- Dried twig of *Artemisia vulgaris* (khempa shing) is burned to repel the insect
- Attract rice bugs to traps, baited with spoiled fish, decaying meat, or chicken manure.

Chemical

- When severe (> 2 bug or nymph/ hill) spray insecticide such as Malathion 50EC @ 2ml/ 1lit of water
- Spray with Cypermethrin 10 EC @0.5 ml/ 1lit of water

Harvesting

The moisture content at harvest should at least be 20-25 %.

- Do not delay harvesting as grain shattering leads to yield loss and also affects milling quality.
- After harvesting, dry the crop for 3-4 days depending on weather condition.
- Threshing can be done using pedal thresher, machine or manually.

Post-harvest management

Post-production includes all operations starting from harvesting: cutting, field drying, stacking or piling, hauling or transporting, threshing, cleaning, drying, storage, milling, and grading. Correct timing of operations to manage grain moisture content is important shown in the table below.

Operation	Desired Moisture Content (%)	Primary Cause of Losses
Harvesting	20-25	Shattering if grain is too dry
Threshing	20-25 for mechanical threshing (varies slightly with variety) <20 % for manual threshing	Incomplete threshing, grain damage and cracking/breakage
Drying	Final moisture content is 14% or lower	Spoilage, fungal damage, discoloration, smell
Storing	<14% for grain storage <13% for seed storage <9% for long term seed preservation	Fungal, insect & rat damage, smell
Milling	14%	Grain cracking and breakage

Timely harvest and post-harvest operations should be done to avoid field losses due to shattering and also to maintain the grain quality of rice. Immediate threshing will reduce losses from birds, insects and rodents. Crop piling (2-4 days) after the harvest, will lead to grain discoloration, germination and spoilage due to mold development.

Seed production

Farmers avail seeds through two main supply systems: formal and informal. Formal seed system comprises the certified seeds supplied by government (research, extension, projects) and private agencies. However, the supply of seed in rural communities is normally met through informal system whereby farmers save their own seed or exchange with another Farmer.

