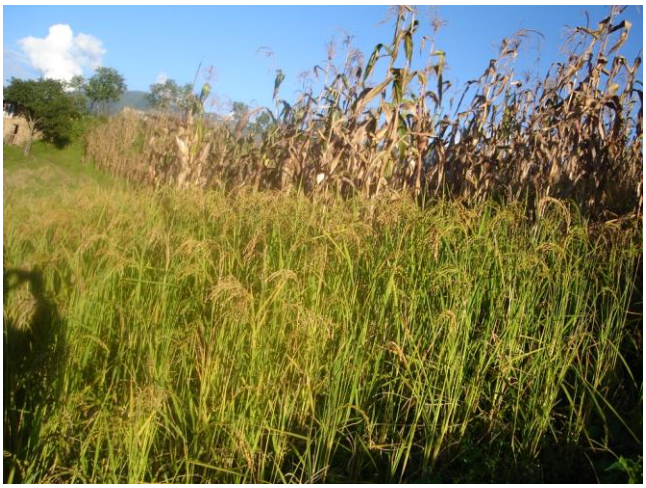
PACKAGE OF TECHNOLOGY FOR RICE PRODUCTION IN BHUTAN

1. PRE-PRODUCTION STAGE

A. IDEAL GROWING CONDITIONS

Criteria	Description
1. Elevation	• Between 250 m such as in the southern foothills of Sarpang, Samtse, and Samdrup Jongkhar to above 2,700 m like in Bumthang • At higher elevations (>2,700 m), rice takes considerably longer to grow and mature due to low temperatures.
2. Ecosystems	• Either in one of the following ecosystems wherever applicable: a) Irrigated ecosystem where rice is grown in terraced fields with assured irrigation water such as those in Paro, Thimphu, Wangdue, and Punakha. b) Rainfed ecosystem where rice cultivation depends on rainfall – in terraced fields – such as those prevalent in the southern foothills. c) Upland ecosystem where rice cultivation also depends on rainfall – but in sloping drylands without terraces – such as those grown in small pockets in the East and Central regions. Rice is usually direct-seeded, either dribbled or broadcast.
3. Soil pH	• Slightly acidic soils with a pH range of 5.5 to 6.5.
4. Soil texture	• Grow ideally in clay and clay-loam soils which have good water-holding and -retention capacity. • Sandy soils quickly lose water and lead to moisture stress. Addition of organic matter helps.
5. Temperature	• Varies at growth stages: a) Seeds germinate and grow at mean temperatures above 14^{o}C. At lower temperatures, growth will be slow. b) Critical temperature for rice flowering and fertilization ranges from 16^{o}-20^{o}C. c) At grain filling and ripening stage, 18^{o}-32^{o}C. d) Temperatures higher than 35^{o}C may affect pollen shedding and thereby grain filling.



Upland rice cultivation in Mongar

Rice cultivation in Bumthang

B. CHOICE OF VARIETY

The choice of a variety depends on altitude, cropping pattern, ecosystem, and growers' preference. The recommended varieties for different altitudes and growing conditions are given below:

Variety Name	Altitude (m)	Recom-mended Dzongkhag	Cropping Pattern and Ecosystem	Days to Maturity	Disease Reaction	Potential Yield (t/ha)	Eating Quality
IR 64	700 - 1,500	• Chhukha • Punakha • Trashigang • Tsirang • Wangdue	As main crop under irrigated conditions	150	Susceptible to blast	5-7	Good, comparable to locals
IR 20913	700 - 1,500	• Punakha • Trashigang • Wangdue	As main crop or as second crop in double cropping	120	Tolerant to blast	3-4	Good
	<700	• Samtse • Sarpang • Zhemgang	First crop in double cropping				
No.11	>1,600	• Haa • Paro	Main crop	>200	Highly susceptible to blast	5-6	Sticky, hard when cold
	700 - 1,500	• Punakha • Thimphu • Wangdue	As first crop in rice-rice rotation	180		3-4	
Bajo Maap-1	700 - 1,500	• Chhukha • Punakha • Wangdue	Main crop; irrigated	150	Tolerant to blast	5-7	Good, comparable to locals

Variety Name	Altitude (m)	Recom-mended Dzongkhag	Cropping Pattern and Ecosystem	Days to Maturity	Disease Reaction	Potential Yield (t/ha)	Eating Quality
Bajo Maap-2	700 - 1,500	• Chhukha • Punakha • Wangdue	Main crop; irrigated	145	Tolerant to blast	5-6	Good, comparable to locals
Bajo Kaap-1	700 - 1500	• Chhukha • Punakha • Wangdue	Main crop; irrigated	155	Tolerant to blast	6-8	Good, comparable to locals
Bajo Kaap-2	700 - 1,500	• Chhukha • Punakha • Wangdue	Main crop; irrigated	155	Tolerant to blast	6-8	Good, comparable to locals
Khumal-2	700 - 1,500	• Dagana • Mongar • Trashigang • T/yangtse • Tsirang	Main crop; irrigated	160	Tolerant to blast	5-6	Good, like locals
Khumal-6	700 - 1,500	• Dagana • Mongar • Trashigang • T/yangtse • Tsirang	Main crop; irrigated	160	Tolerant to blast	5-6	Good, like locals
BR 153	<600	• S/jongkhar • Samtse • Sarpang	Main crop; irrigated or rainfed	160	Tolerant to blast	3-5	Acceptable
Khangma Maap	>1,600	• Haa • Paro, Thimphu • Higher areas of other Dzongkhag	Main crop; irrigated or upland	>180	Resistant to blast	4-6	Good, like locals
Yusirey Maap	>1,600	• Haa • Paro • Thimphu	Main crop; irrigated	>180	Resistant to blast	4-6	Good
Yusirey Kaap	>1,600	• Haa • Paro, Thimphu • Higher areas of other Dzongkhag	Main crop; irrigated	>180	Resistant to blast	4-6	Good
Jakar Reynaab (Paro China)	>2,500	• Bumthang • Haa • Parts of Wangdue	Main crop; irrigated	>200	Susceptible to rice blast	5-6	Good

Characteristics of Main Rice Varieties Grown in Bhutan

IR 64

- Developed by IRRI
- High yielding tropical semi-dwarf variety (80-90 cm tall)
- Grain quality similar to local white rice "Zakha"
- Milling recovery: 65%
- Slender white grain

Bajo Maap-1

- Developed by RC Bajo
- Semi-dwarf variety, about 100 cm tall
- Resistant to lodging and responsive to fertilizers
- Light red grains

Close-up view of Bajo Maap-1 variety

Bajo Maap-2

- Developed by RC Bajo
- Semi-dwarf variety (about 100-110 cm tall)
- Resistant to lodging and responsive to fertilizers
- Deep red grains

Rice field grown with Bajo Maap-2

Bajo Kaap-1

- Developed by RC Bajo
- Semi-dwarf variety (about 100 cm tall)
- Resistant to lodging and responsive to fertilizers
- Slender white grains

Close-up view of Bajo Kaap-1 variety

Bajo Kaap-2

- Developed by RC Bajo
- Semi-dwarf variety (about 90-100 cm tall)
- Resistant to lodging and responsive to fertilizers
- Slender white grains

Rice field grown with Bajo Kaap-2

Khumal 6

- Introduced from Nepal
- Medium variety (about 1.1 m tall)
- Milling recovery: 66%
- White grains

Close-up view of Khumal 6 variety

Khangma Maap

- Introduced from Nepal
- Tall variety (over 120 cm tall
- Resistant to blast disease
- Roundish red grains

Rice field grown with Khangma Maap

BR 153

- Introduced from Bangladesh
- Medium tall variety (about 100-110 cm tall)
- Tolerant to poor and marginal growing conditions
- White grains

Close-up view of BR 153 variety

Yusirey Maap

- Developed by RC Yusipang
- Tolerant to pests and diseases such as blast.
- Difficult to thresh manually
- Bold red grains.

Rice field grown with Yusirey Maap

II. PRODUCTION STAGE

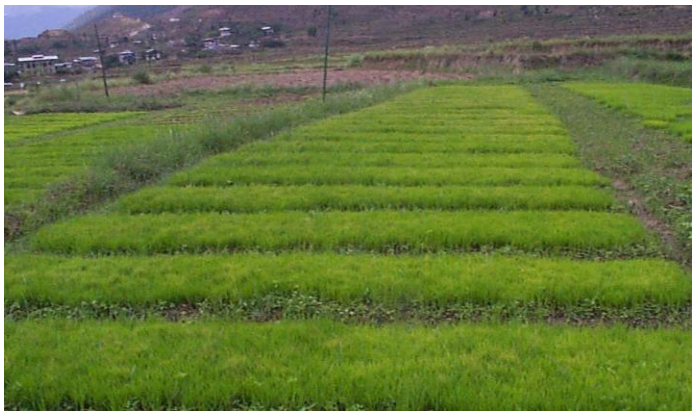
1. Nursery Preparation

There are three main methods of raising rice seedlings in Bhutan as described below, including the conditions as to which method to adopt:

Method	Conditions for Adoption?			
	Irrigation	**Weeds**	**Temperature**	**Altitude**
1. Semi-dry bed	Not assured	Shochum areas	Low (<18^{o}C) at seedling stage	High and mid (>1000_masl)
2. Wet bed	Assured	No shochum	High (>18^{o}C)	Mid and low (<1000 masl)
3. Polytunnel	Not assured	Shochum areas	Low (<15^{o}C)	High and mid (>1000 masl)

A. Semi-Dry Bed Method

- Prepare a well-leveled field with fine, pulverized soil.
- Apply 3 kg of well-rotten Farm Yard Manure (FYM) for a 1 m x 3 m seedbed. Mix them thoroughly with the soil.
- Make raised seedbeds 10-13 cm high, 1 m wide, and any convenient length (5-10 m)

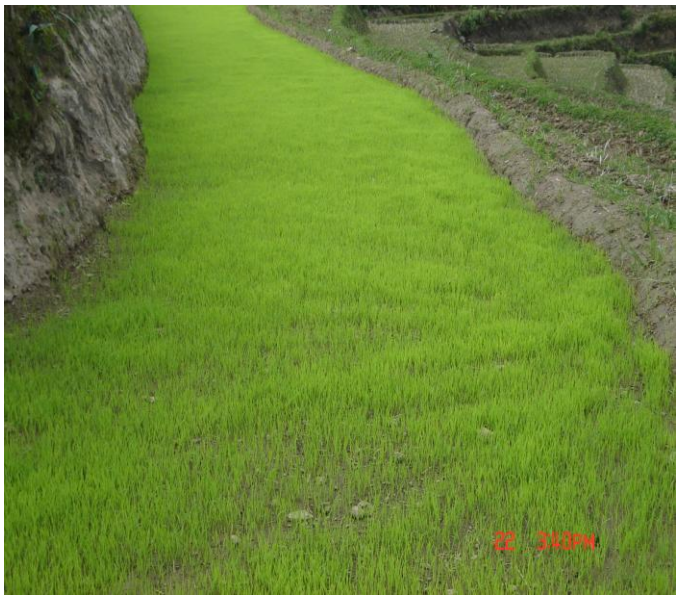


Rice seedbed using semi-dry bed method

- Broadcast unsoaked dry seeds uniformly on the seedbeds. One "Drey" or 1.2 kg seed is sufficient for a 1 m x 6 m area.
- Cover the seeds using a thin layer of fine soil mixed with well-decomposed FYM.
- Irrigate the seedbeds immediately after sowing. The seedbeds should be just soaked. Never flood.
- Check the moisture of the seedbeds and irrigate when necessary.
- Seedlings are ready for transplant 40-60 days after sowing, depending on the altitude and temperature.

B. Wet Bed Method

- Plough, puddle, and level a conveniently-located plot. Apply enough FYM before puddling.
- Make slightly raised seedbeds, 10-13 cm high, 1 m wide, and any convenient length.
- Soak the seeds in clean water for 24-36 hours. Then rinse the seeds, drain, and incubate them for 36-48 hours. During incubation, keep them moist and warm in half-filled, loosely-tied sacks. Every 12 hours, drench the sacks and turn them upside down to even out the temperature.



Rice seedbed using wet bed method

- Broadcast the pre-germinated seeds uniformly on the seedbeds. One Drey of seeds is enough for a 1 m x 6 m seedbed.
- Maintain just enough water to continuously saturate the seedbeds for the first week. Thereafter, gradually increase the water level as the seedlings grow. Never let the seedbeds dry out.
- The seedlings are ready for transplant 20-25 days after sowing depending on the temperature.

C. Polytunnel Method

A polytunnel cover is used over the seedbed to protect seedlings – raised as first crop in rice double cropping – from cold and provide higher seedbed temperatures for seed germination and growth. Minimum temperature required for the germination of rice seed ranges from 9^{o}-13^{o}C. (Note: the normal air temperature during the first week of February in Wangdi and Punakha Valley averages only 4^{o}-8^{o}C). A polytunnel cover increases the temperature to 10^{o}-12^{o}C making seed germination and growth possible.

- Prepare a well-leveled field with fine, pulverized soil.
- Make raised beds 4 to 5 inches (10-13 cm) high, 1 m wide, and of any convenient length.
- Sow seeds evenly on the seedbed as in a semi-dry bed nursery.
- Cover the seeds with fine soil mixed with FYM (1:1 mixture).
- Sprinkle water or irrigate lightly through the channels to soak the beds. Never flood.
- Put bamboo or "Kempah" hoops over the beds 80 cm apart down the length of the bed, pushing the ends firmly into the soil.

- Place medium-weight transparent polythene sheet over the hoops long and wide enough to cover the beds. Cover the edges of the polythene with soil to hold them down to the ground.
- Check the moisture frequently to ensure that there is enough supply and, whenever necessary, irrigate by raising the polythene sheet.
- After seedling emergence, open the plastic tunnel every 9 to 10 a.m. and close it at 3 to 4 p.m.
- Irrigate the nursery, as and when required, preferably during the day.

Seedbeds with polytunnel cover

- Seedling vigor will depend upon the soil temperatures and growing conditions. Normally, seedlings attain 3-4 leaf stage after 40-45 days of sowing, which are ready for transplanting.

2. Field Preparation

- Pre-irrigate the field, if it is dry, before ploughing.
- Plough 2-3 times thoroughly and flood it thereafter.
- Drain the water slightly and plough/rotovate/harrow as needed.
- Repair and maintain bunds and incorporate chemical fertilizers, if any.
- Do final puddling and levelling just before transplanting.

3. Manure and Fertilizer Application

- Apply about 8-10 t/ha FYM basally (for medium altitude areas, about 7-15 t/ha), and topdress with 35 kg N/ha 35-40 days after transplanting.
- If adequate manures are not available, apply chemical fertilizer at the rate of 30:12:8 kg NPK/acre. Apply half dose of Nitrogen and full dose of Phosphorus and Potash as basal application.
- Topdress the remaining N two times at tillering and at panicle initiation equally.
- Wherever possible, carry out soil tests by sending soil samples to the National Soil Service Center (NSSC) to determine the exact nutrient requirement.
- When using green manure preferably in the mid and low altitudes, incorporate 6-8 week's old *Sesbania aculeata* (Dhaincha) before transplanting of rice. Topdress with N at the rate of 35 kg/ha for higher yields.

Pre-Rice Green Manuring

Sesbania aculeata (Dhaincha) is a leguminous crop producing 8-25 t/ha of green matter that will add about 60-90 kg of N when incorporated. This amount would equal an application of 3-10 t/ha FYM on the basis of organic matter and N contribution.

Close-up view of Dhaincha plant

- Prepare the field as normally done for any dryland crop like wheat.
- Pre-irrigate, if necessary, plough the field, and break soil clods to attain a good tilth. Do light planking after sowing to cover the seeds.
- Apply P at 16 kg/acre during land preparation.
- Scarify the seeds before sowing by rubbing with sand on a hard surface.
- Sow the seeds in April after wheat harvesting at 16-20 kg/acre.
- Incorporate the crop at 45-60 days after sowing by ploughing. If the plants are tall, chop them into small pieces using conventional ploughs.
- Transplant rice seedlings immediately after incorporation up to about two weeks. The seedlings may exhibit leaf yellowing soon after transplanting due to temporary immobilization of inorganic N in the soil. Seedlings will recover once mineralization begins.

4. Rice Establishment

Establishing the rice crop in Bhutan is either by direct seeding or transplanting, although the latter is commonly practised by Bhutanese farmers.

Method	Advantages	Disadvantages	Altitude Zone
1. Direct seeding	• Less labour required • Matures earlier • Similar yield as in transplanted crop	• Difficult to get a good crop stand • More weeds problem	Mid and low

2. Transplanting	• Good, optimum crop stand • Easier weed control	• Requires more labour in seedling uprooting and transplanting	All zones

A. Transplanting

- For mid-altitudes, do transplanting in May – June. Use the traditional or random method of transplanting if the weed pressure is expected to be low, if Butachlor is intended to be used for weed control, and if the terraces are narrow and small.
- Do line planting when controlling weeds using a rotary weeder. Use planting rope to maintain row spacing of 20 cm and plant-to-plant spacing of 15-20 cm within the rows. Avoid wide spacing particularly in random transplanting.
- A plant density of 25-35 hills per square meter is optimum. Plant 2-3 seedlings per hill at 20 cm x 20 cm distance.

B. Direct Seeding (wet broadcast)

- Prepare the land similar to any transplanted rice crop. Level the field properly.
- After final land preparation, allow the mud to settle overnight. Keep water level to the minimum.
- Broadcast pre-germinated seeds (that is, soaked for 24 hours and incubated for 36-48 hours) evenly.
- Walk backwards while seeding and avoid making too many mud depressions that collect water and rot the seed.
- Keep the water level as minimum as possible until the seeds secure their roots and emerge (that is, 2-5 days but may take longer if the temperature is low).
- Increase the water level gradually as seedlings grow.
- Use a seeding rate of 70-90 kg/ha.
- Do direct seeding 15-20 days prior to transplanting depending on the cropping season, varieties, and growing areas.

5. Weed Management (see also Pests Management)

- Where weed pressure is expected to be low or moderate, do hand weeding at least two times, that is, at 20 and 40 days after transplanting. If hand weeding is to be done, keep in mind to closely space the plants and perform the first weeding not later than 30 days after transplanting.
- If weed pressure is expected to be high, use line planting and rotary weeding. If line planted, do two rotary weedings, that is, at 20 and 40 days after transplanting.
- If there is no or little shochum weed but weed pressure is expected to be high, use Butachlor at 12-16 kg per acre and apply 3-6 days after transplanting. Do not use Butachlor in areas heavily infested with shochum.
- In shochum-severe areas, do hand weeding 3-4 times thoroughly, by removing and destroying the weeded shochum biomass. To minimize shochum problem, adopt

cultural methods like increased tillage, deep ploughing, and restricting the physical movement of plant parts from one field to another.

- Since weeding is laborious and the use of herbicides is not environment-friendly, use indirect complementary weed control methods like good land preparation, proper water management, and use of weed-free seedbeds and seeds.

6. Irrigation Management

- Avoid letting the soil crack and keep the fields saturated or moist. About 800-1200 mm water is needed for a rice cropping season.
- After transplanting, keep the water level as minimum as possible for about 4-7 days until the plants recover.
- Thereafter, gradually increase the water level up to 5-7 cm and ensure enough water from tillering to flowering.
- Irrigate at short intervals (3-5 days) but do not allow the field to dry-up and crack.
- Do not subject the rice plant to water stress during the flowering stage as this is its most critical stage of growth.
- Drain the water from the field 10-15 days before harvest.

7. Harvesting

- Under normal conditions, begin harvesting from first week of October in the Wangdue-Punakha valley.
- Harvest the crop as soon as it matures, when at least 85% of the upper portion of panicles turns straw coloured.
- For some varieties like No. 11 wherein some leaves and stems may still be green at grain maturity, use days to maturity of a particular variety as basis for harvesting schedule.
- Use serrated sickles to harvest the crop manually. Where available, powered machines or reapers can be used to harvest rice.