Stress-Tolerant Rice for Africa and South Asia

Guidelines for Submergence-Tolerant Rice Varieties: Production and Management

Accelerating the development, delivery, and adoption of improved rice varieties
**Introduction**

Water stress in rainfed lowland ecosystems is the main constraint to rice productivity: either insufficient water results in drought stress or too much water causing flooding and submergence. Submergence stress is estimated to cause more than US$650 million in annual losses in production, and this problem regularly affects 15–20 million ha of rice lands in Asia. Short-term flash floods (for up to 2 weeks) can occur at any stage of plant development, sometimes more than once, resulting in severe yield losses.

In direct-seeded rice, submergence after sowing substantially reduces stand establishment because of the high sensitivity of existing rice varieties. Additionally, waterlogging or stagnation for up to 50 cm for a few months during the growing season is a serious problem in some rainfed areas. Modern rice varieties are not adapted to these conditions and this is probably the reason these varieties are not widely adopted in areas prone to flooding. As a result, farmers continue to grow their local landraces even though their yield is low.
Ten steps to the production and management of rice in submergence-prone areas are described here.

**Step 1. Choose the right rice genotypes**

Table 1 in page 11 shows the available submergence-tolerant rice varieties at IRRI. Use good-quality seeds to realize the full potential of a chosen variety. In choosing the right rice varieties, consider other characteristics such as high yield and desired maturity, resistance to prevailing pests and soil problems, and good eating quality.
**Step 2. Raise healthy and vigorous seedlings**

**Wetbed method:**

- Soak seeds in the morning, incubate seeds the next morning, and then sow seeds the following morning.
- Choose a seedbed site that is near a water source, with good soil that is disease- and weed-free, and far from street lights. Apply or incorporate organic matter into the soil to make it light and porous and to facilitate seedling pulling.
- After incubation, sow pregerminated seeds in the seedbed at 50–75 g per m². For commercial rice production, farmers may use 20–30 kg of seeds per ha. High seed rates result in thinner and weaker seedlings likely to be damaged by early floods. Water the seedbed 2–3 days after sowing (DAS). Keep it moist, not flooded.

**Seedbed preparation**

**Take good care of seedlings:**

1. Proper nutrition: 6 g of N, 4 g of P₂O₅, 2 g of Zn, and 1 kg of farmyard manure (FYM) per m² of the nursery area (equivalent to a rate of 60 kg N, 40 kg P₂O₅, 20 kg Zn, and 10 t per ha of FYM) is optimum in areas with low fertility (e.g., in sandy, loamy soil). Do not apply too much nitrogen (less than 3 g N per m²) if the soil is fertile. Farmyard manure is helpful if available and should be combined with inorganic fertilizers.

2. Pest management: Leaf-feeding insects seldom cause yield losses in the seedbed. If tungro virus inoculum or stem borers are present, protect your seedlings with the appropriate recommended pesticides.
Step 3. Prepare land thoroughly

- Prepare land 3 weeks before transplanting. Fix all dikes, soak the field for 1 day to soften the soil, and then plow to a depth of at least 10 cm to incorporate all weeds and rice stubble for proper decomposition.
- Maintain water in the field after plowing to prevent nitrogen loss from the soil and to hasten decomposition of rice stubble.
- Puddle the soil by harrowing 3–5 days after plowing.
- Begin a second harrowing after 5–7 days. Keep the field flooded.
- Harrowing and final leveling should be completed a day before the scheduled transplanting.

Step 4. Do pest management before transplanting

Insects—plant during the regular season (not too early or late) to avoid pest infestation.

Diseases—destroy all infected rice stubble, ratoons, and weeds.

Rodents—destroy all breeding sites of rodents.

Golden apple snail—herd ducks in the field, hand-pick snails, repair dikes, and control water; put screen wires along water outlets; and construct small canals near dikes and alternately drain and flood the field so snails will transfer to small canals where they can be caught easily. Transplanting older seedlings also helps to reduce snail damage.
Use attractants such as leaves of ‘gabi’ (Colocasia esculenta), banana (Musa paradisiaca L.), papaya (Carica papaya L.), and trumpet flower (Bignonia capreolata/Doxantha capreolata), and old newspapers for easy collection of golden apple snails. The critical time for snail control is after transplanting and when the flood subsides 1 to 2 weeks after transplanting.

Weeds—thorough land preparation controls most weeds.

**Step 5. Do nutrient management before transplanting**

- One or two days before transplanting, drain water up to the saturation point. If flooding is highly likely to occur, do not apply basal organic and inorganic N fertilizer before final leveling.
- Dip seedlings in 2% zinc oxide solution before transplanting or broadcast 10–20 kg/ha zinc sulfate into the flooded field after the first irrigation if the soil is known to be deficient in zinc.
- It is important to level the field properly to attain uniform water depth in the field. This helps suppress weed growth. Also maximizes fertilizer availability in the field.
Step 6. Plant and use appropriate plant spacing

Transplanting

Timing:
• Use 21-day-old seedlings for early-maturing varieties such as IR64-Sub1 and older (about 35–45 days old) seedlings for latematuring varieties. However, if early flooding is anticipated, use older seedlings (35 to 45 d) in all cases.
• Transplanting should be done immediately after uprooting of the nursery.
• Make sure the seedling height at transplanting is greater than the water depth in the field; sensitivity to submergence is high at this early stage.

Plant density and spacing:
• Use 2–3 seedlings per hill.
• Use closer spacing (15 × 15 cm) in the field if a high level of standing water is expected, as tillering will be reduced.

Direct seeding

Dry seeding

• In rainfed and deepwater ecosystems, dry seed is manually broadcast onto the soil surface and then incorporated either by plowing or by harrowing while the soil is still dry. Care is taken not to incorporate the seed too deeply into clay soils or where surface sealing is a problem.
• In some deepwater rice areas, the seed is not incorporated after broadcasting. Germination occurs following rain or floods. To achieve good crop establishment, consider the following factors: use high-quality seeds, level the soil well, and monitor water availability.
• The target number of plants to be established ranges from 100 to 150 per m². To meet this target, seeding rates vary between 80 and 250 kg per ha. Some plant rearrangement (transplanting) is normally undertaken within the field after establishment to even up plant stands.
Step 7. Use postsubmergence nutrient management in the main field

- If the floodwater goes down (field water depth <15 cm) early (15 to 30 days before heading), responses to fertilizer, particularly nitrogen, will be good.
- Fertilizers can be applied within 1 week after the flood subsides and again at 15 to 20 days after the first application. Apply another dose of 30-45 kg of N per ha 5-7 days before panicle initiation.
- Apply about 30–50 kg of N, 20–30 kg of P₂O₅, and 20–30 kg of K per hectare.
- If the water level is high in the field, slow-release and coated nitrogen sources are preferred, if available.

Step 8. Use nutrient management at the vegetative and reproductive stages when water level is not too high

**Vegetative stage**

Apply fertilizer when there is enough water in the field for uniform distribution and proper uptake by the plants.

Apply 2 bags of 14-14-14 as basal and 1 bag of urea (45-0-0) at 5-7 days before panicle initiation (DBPI) or depending on the fertilizer recommendation in the area.

Apply at 45–50 days after sowing for early-maturing varieties and at 55–60 DAS for medium-maturing varieties.

If zinc deficiency symptoms appear, drain the field or broadcast 10–20 kg/ha of zinc sulfate into the flooded soil. Symptoms are slight yellowing of leaves and low tiller formation.
• Do not topdress while the leaves are wet. The fertilizer will stick to the leaves and may cause leaf burn. Dissolved fertilizer will be lost in the air when the droplets dry.
• Do not topdress when there is impending heavy rain because the fertilizer will be washed out in the field.
• Keep fields free from weeds. Weed before applying fertilizer.

Reproductive stage

• Topdress 1 bag of urea (45-0-0) at late booting/flowering (optional, depending on weather conditions).
• Applying fertilizer at flowering increases the weight of grains. However, too much nitrogen at later stages of growth increases spikelet sterility and induces the production of late tillers.
• Uneven plant growth means that fertilizer application in the field was not uniform and lodging may result from too much fertilizer.
Step 9. Do pest management at vegetative and reproductive stages

Vegetative stage
• The critical time to control weeds is from 25 to 35 days after transplanting (DAT). Weeds can be controlled manually or by using herbicides.
• For insect pests, regular or synchronized planting (not too early or late) can help avoid pest infestation. During the early growth stage of the crop (30–40 DAT), it is not necessary to spray against leaf-feeding insects as the rice crop can compensate for leaf damage.

Reproductive stage
• During this stage, most pests are still present but pose no significant damage to the rice crop. However, a late attack of stem borers at booting results in many whiteheads, which may cause a significant yield loss if left unchecked. Rice bug attacks during the late reproductive stage and up to the ripening stage of the crop.
• Leaffolders and mites must also be checked if found numerous at this stage. Brown planthopper may cause hopper burn if its population remains unchecked, while green leafhopper may spread tungro virus if there is a source of inoculum in the field.
Step 10. Follow harvesting and postharvest operations

- Harvest the rice when 80% of the grains are mature. Grains at the tip of the panicle must be hard and golden yellow, even while grains near the base of the panicle are less mature. A delay in harvesting will cause the grains at the tip to shatter.
- During the wet season, drain the field 2 weeks before harvest. However, during the dry season and depending on your soil type, gradually drain the field up to the saturation point, preventing drying of the soil as water stress at this stage will affect grain quality. Grains must be threshed immediately to minimize field losses and quality problems.
- Thresh, clean, and dry grains immediately. Newly harvested rice has a high moisture content (20–26%) and must be dried immediately to 14% for safe storage, better grain quality, and a higher commercial price.
- For sun-drying, spread the rice in layers 2–4 cm thick on concrete pavement, and mix every 30 minutes for uniform drying and to prevent overheating. Use mechanical dryers if available.
- For storing seed, rice should be dried at 14% moisture content.
- Milling losses arise from improper adjustment of the machine or improper milling equipment, a lack of trained operators, or poor paddy quality.
- Poor and inefficient harvest and postharvest practices can cause a 9–23% loss.
Table 1. Available submergence-tolerant rice varieties and their characteristics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Background/variety</th>
<th>Days to flower</th>
<th>Plant height (cm)</th>
<th>Amylose content</th>
<th>Country Released/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR 05F102</td>
<td>Swarna</td>
<td>105</td>
<td>85</td>
<td>High</td>
<td>India, 2009 as improved Swarna and Nepal, 2011 as Swarna-Sub1; Bangladesh, 2010 as BRRI Dhan 51; Indonesia, 2009 as INPARA-5</td>
</tr>
<tr>
<td>IR 07F102</td>
<td>IR64</td>
<td>85</td>
<td>95</td>
<td>Intermediate</td>
<td>Philippines, 2009 as Submarino; Indonesia, 2009 as INPARA-4</td>
</tr>
<tr>
<td>IR 07F290</td>
<td>BR11</td>
<td>100</td>
<td>130</td>
<td>High</td>
<td>Bangladesh, 2011 as BRRI Dhan 52</td>
</tr>
<tr>
<td>IR07F101</td>
<td>Samba Mahsuri (BPT5204)</td>
<td>95-105</td>
<td>80-85</td>
<td>High</td>
<td>Nepal, 2011 as Samba Mahsuri-Sub1</td>
</tr>
<tr>
<td>IR70213-9-CPA-12-UBN-2-1-3-1</td>
<td>INPARA</td>
<td>90</td>
<td>110</td>
<td>High</td>
<td>Indonesia, 2008 as INPARA-3</td>
</tr>
<tr>
<td>NDR 8002</td>
<td>IR 67493-M-2</td>
<td>145</td>
<td>105</td>
<td>Long fine grain</td>
<td>India, 2005</td>
</tr>
<tr>
<td>NDR 9830144</td>
<td>IR 68828-24-NDR-1-1-1-1</td>
<td>145</td>
<td>110</td>
<td>Long fine grain</td>
<td>India, 2009</td>
</tr>
<tr>
<td>NDR 9830135</td>
<td>IR 68850-71-NDR-1-1-1-1</td>
<td>150</td>
<td>120</td>
<td>Long bold grain</td>
<td>India, 2009</td>
</tr>
<tr>
<td>NDR 9830132</td>
<td>IR 68815-1-NDR-1-1-1-1-1</td>
<td>150</td>
<td>120</td>
<td>Long bold grain</td>
<td>India, 2009</td>
</tr>
</tbody>
</table>

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