IRRI-STRASA

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.

IR64-Sub1

INPARA-3

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 m^2. 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.

Take good care of seedlings:

1. Proper nutrition: 6 g of N, 4 g of P_2O_5, 2 g of Zn, and 1 kg of farmyard manure (FYM) per m^2 of the nursery area (equivalent to a rate of 60 kg N, 40 kg P_2O_5, 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 m^2) 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.

Land preparation

Photo: A. Pamplona

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.

Banana (*Musa paradisiaca* L.)

Papaya (*Carica papaya* L.)

Photos: R. Baltazar

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.

- 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.

Fertilizer (urea) application at vegetative stage.

Photos: IRRI-CPS

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.

Farmers weeding a rice field in Vietnam.

Photos: IRRI-CPS

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.

Harvesting a flooded rice field.

Table 1. Available submergence-tolerant rice varieties and their characteristics.

Name	Background variety	Days to flower	Plant height (cm)	Amylose content	Country Released/Year
IR 05F102	Swarna	105	85	High	India, 2009 as improved Swarna and Nepal, 2011 as Swarna-Sub1; Bangladesh, 2010 as BRRI Dhan 51; Indonesia, 2009 as INPARA-5
IR 07F102	IR64	85	95	Intermediate	Philippines, 2009 as Submarino; Indonesia, 2009 as INPARA-4
IR 07F290	BR11	100	130	High	Bangladesh, 2011 as BRRI Dhan 52
IR07F101	Samba Mahsuri (BPT5204)	95-105	80-85	High	Nepal, 2011 as Samba Mahsuri-Sub1
IR70213-9-CPA-12-UBN-2-1-3-1	INPARA	90	110	High	Indonesia, 2008 as INPARA-3
NDR 8002 (Narendra 8002)	IR 67493-M-2	145	105	Long fine grain	India, 2005
NDR 9830144 (Narendra Mayank)	IR 68828-24-NDR-1-1-1-1	145	110	Long fine grain	India, 2009
NDR 9830135 (Narendra Jalpushp)	IR 68850-71-NDR-1-1-1-1	150	120	Long bold grain	India, 2009
NDR 9830132 (Narendra Naraini)	IR 68815-1-NDR-1-1-1-1	150	120	Long bold grain	India, 2009
IRRI 119	PSB RC68	98-100	121-125	Soft	Philippines, 1997 and Myanmar, 2003

Source: **Alvaro Pamplona, Sudhansu Singh, Abdelbagi Ismail (2007, 2009) and Aris Hairmansis (2008).**

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