Adaptability Traits of Semi-Deep Water Rice (*Oryza sativa* L.)

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Farming rice in flood-prone areas is never easy. Sudden floods, stagnant water, and changing water levels often threaten both crops and livelihoods. Semi-deep water rice (*Oryza sativa* L.) has naturally adapted to these conditions, making it a trusted crop for farmers in many parts of South and Southeast Asia. Its survival depends on a few key traits: the ability to elongate its stem as water rises, stand back up through kneeing ability after floods recede, balance shattering for both survival and harvest, and adjust its overall growth form through strong phenotypic plasticity. Together, these traits allow the plant to survive floods, recover quickly, and still produce grain. Semi-deep water rice is not just a crop—it is a symbol of resilience, shaped by nature and farmers alike, and remains vital for food security in flood-affected regions under a changing climate.

Key words: Elongation Ability, internode length**,** kneeing ability, shattering, phenotypic plasticity.

Introduction

In many flood-prone regions of South and Southeast Asia, rice farmers work with nature rather than against it. Semi-deep water rice (*Oryza sativa* L.) is a fine example of this harmony. Grown in fields where water levels can rise to 50–100 cm for weeks, this type of rice has learned to survive—and yield—under challenging conditions. What makes semi-deep water rice special is its ability to adjust. When water levels rise, the plant gently elongates its stem to keep its leaves and panicle above water. When floods recede and plants fall flat, they show a remarkable recovery through kneeing ability, bending their upper stem nodes to lift the panicle back into an upright position. This simple movement saves the grains from rotting or being lost to pests. Along with features like aerial root formation and tolerance to low-oxygen soils, these traits help the crop withstand repeated flooding. As climate change increases the uncertainty of rainfall and floods, semi-deep water rice stands as a living example of resilience—shaped by nature and refined by farmers over generations. To survive these extreme conditions, shallow deep, semi-deep and deep water rice possesses four remarkable biological superpowers: Elongation Ability, Kneeing Ability, Shattering Ability, and a flexible Phenotypic Plasticity.

Elongation Ability: The Underwater Snorkel
What is elongation ability?

Elongation ability is the **rapid increase in stem or internode length** when water level rises. The most famous trait of semi-deepwater and deepwater rice is, its ability to grow at an incredible pace to keep its head above water. While standard rice might grow a few centimeters a week, semi deep water and deep water rice can elongate its stem (internodes) by as much as 20–25 cm in a single day (Minami, A. *et al.*). This process is triggered by the accumulation of ethylene gas within the plant tissues when it becomes submerged. This gas acts as a signal to boost growth hormones like gibberellins ,causing the cells in the stem to

rapidly divide and stretch. By staying above the water line, the plant can continue to photosynthesize and breathe(Voesenek LACJ, Bailey-Serres J).

Why is it crucial?
- In semi–deep water fields, water can rise suddenly.
- Rice plants must keep their leaves and panicles above water to survive.

How it helps
✔ Prevents suffocation.
✔ Ensures photosynthesis.
✔ Supports flowering and grain filling.

Deep-water rice varieties can elongate several centimeters per day, a remarkable survival strategy.

Kneeing Ability: Standing Up After the Flood.

What is kneeing ability?
Kneeing ability is the capacity of a rice plant to bend nodes which are near to the panicle and then turn upward, forming a knee-like structure (Catling, D). Once the floodwaters recede, the long, spindly stems of semi-deepwater and deepwater rice are often left lying flat on the muddy ground a state known as "lodging." If the plant stayed flat, the grain (panicle) would rot in the mud or be eaten by pests. This is where Kneeing Ability (negative gravitropism) comes in. The upper nodes of the fallen stem have the unique ability to bend upward , effectively "kneeling" to lift the reproductive parts of the plant back into a vertical position. This ensures the rice grains remain dry and accessible for harvesting.

Why is it important?
In semi–deep water areas:
- Sudden floods or strong winds often lodge (flatten) the crop.
- Plants with good kneeing ability recover their upright position, allowing normal growth.

Farmer benefit
Better survival after floods.
Improved panicle emergence.
Reduced yield loss due to lodging.
Kneeing ability acts like a *self-rescue mechanism* for rice plants.

Shattering Ability: The Wild Survival Seed-Drop

Shattering refers to the natural detachment of ripe rice grains from the plant.

What is shattering ability?
Shattering ability refers to how easily grains fall off from the panicle after maturity.
- **In Wild Rice:** High shattering is an evolutionary advantage; it allows the seeds to fall into the water or soil to ensure the next generation survives.
- **In Cultivated Rice:** Farmers generally prefer "low-shattering" varieties so the grain stays on the stalk until it can be harvested.

In semi deepwater and deepwater ecosystems, many traditional varieties maintain a degree of shattering ability. This is a double-edged sword: while it helps the plant persist in the wild, too much shattering leads to significant yield loss for the farmer. Modern breeding aims for a "moderate" shattering ability—strong enough to hold the grain through the wind and water, but easy enough to thresh later.

Why does it matter in deep water rice?
- Traditional deep-water rice varieties often show high shattering.
- This is useful in **natural seed dispersal**, but harmful during harvesting.

Pros and cons of shattering
Advantage: Natural regeneration in flooded fields.
Disadvantage: Grain loss before or during harvest.

Breeding goal
Scientists aim for moderate shattering:
- Not too high (to prevent yield loss)

- Not too low (to maintain adaptability)

Phenotypic Ability (Plasticity): The Ultimate Shape-Shifter

Phenotypic ability, or phenotypic plasticity, is the plant's capacity to change its physical characteristics (its "phenotype") in response to its environment. Semi-deepwater and deep water rice is a master of this.

Depending on the water depth, the same rice variety can look completely different:

- **In Semi-deep Water:** It remains a relatively short, sturdy plant with high tillering (more stems).
- **In Deep Water:** It shifts its energy away from tillering and into massive stem elongation and the development of "aerial roots" that sprout from the nodes to absorb nutrients directly from the floodwater.

Deepwater rice. (2021). *Banglapedia*. (Describes adaptations including stem elongation and development of nodal roots that absorb nutrients from floodwater).

This "ability" is what makes semi deepwater and deepwater rice so reliable. It doesn't just grow; it *adapts* its entire architecture to match the severity of the season.

What is phenotypic ability?

Phenotypic ability refers to the overall visible performance of the plant, including:

- Plant height
- Tillering
- Leaf colour
- Panicle type
- General plant vigor

Why is it important?

- Farmers prefer plants that look healthy and uniform.
- Good phenotypic ability indicates adaptation to local conditions.

Role in selection

✔ Helps breeders select superior lines

✔ Reflects combined effect of genes and environment

✔ Important for farmer acceptance

Conclusion: Nature's Smart Design for Flooded Fields

Semi–deep water rice is a perfect example of natural adaptation.

- Kneeing ability helps plants stand back up
- Shattering ability influences yield stability
- Elongation ability allows survival under rising water
- Phenotypic ability ensures good field performance

Understanding and improving these traits is essential for:

- Sustainable rice production
- Climate-resilient agriculture
- Food security in flood-prone regions

By conserving and improving these unique rice traits, we protect both farmers' livelihoods and future harvests. Rice cultivation in flood-prone ecosystems is a constant challenge for farmers. In many parts of eastern India, Odisha, West Bengal, Assam, and coastal belts, rice fields experience temporary flooding, water stagnation, and sudden rise in water levels. To survive under such harsh conditions, farmers traditionally grow semi-deep water , a unique group of rice adapted to variable water depths. The survival and productivity of these rice types depend on four remarkable adaptive traits:

kneeing ability, shattering ability, elongation ability, and phenotypic ability. Together, these traits help the crop withstand floods and ensure harvest even under adverse environments.

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