

The Role of Culm Strength in Rice Farming

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Introduction

Rice is one of the most essential staple foods globally, feeding over half of the world's population and forming a vital part of daily meals in many countries. However, rice production involves more than just maximizing grain yield; the plant's physical strength is equally crucial. A key structural feature of the

rice plant is its culm or stem, which plays a vital role in maintaining the plant's stability. The culm supports the plant's ability to stand tall and withstand challenging conditions such as heavy rain, strong winds, and the weight of its grain-filled panicles, ensuring both yield quality and resilience.

Importance of Culm Strength in Plants

If the stems of the rice plants are weak, they may bend or break, causing the entire field to flatten, a problem known as lodging. Lodging makes harvesting difficult for farmers and can lead to significant crop losses. Grains from lodged plants are often of poor quality, and in severe cases, farmers may lose a substantial portion of their harvest. One of the primary causes of lodging is weak culms. Rice plants

with strong stems, however, are better equipped to support their grain-laden panicles and remain upright even in adverse weather. This is particularly crucial for high-yielding rice varieties, which produce more grains and place extra weight on the plant's stems. By enhancing culm strength, we can reduce lodging, improve grain quality, and help farmers achieve higher yields with less effort.

Factors Contributing to Culm Strength in Plants

The strength of a plant's culm (stem) is influenced by several factors. Understanding these contributors helps in breeding and cultivating crops with robust culms to improve yield stability and resilience.

Stem Thickness and Material: Strong rice plants typically have thicker stems that serve as a sturdy backbone to support the plant. The strength of the culm primarily depends on the materials found in the walls of its cells. These include: Cellulose and Lignin. Cellulose acts like the plant's steel rods, providing tensile strength. Lignin functions like concrete, adding

rigidity and resistance to bending or breaking. Together, these materials form a framework similar to a building's structural skeleton, offering the plant the support it needs to withstand external pressures such as heavy grain loads, strong winds, and rain.

Height of the Plant: Taller plants are more prone to lodging because their stems must support greater weight, especially from heavy grain loads at the top. The tall culms act like long levers, making them less stable and more susceptible to bending or breaking under pressure from wind, rain, or grain weight. In

contrast, shorter plants, such as semi-dwarf rice varieties, are naturally sturdier, as their shorter stems provide better structural stability. Less prone to lodging because their reduced height minimizes leverage and allows them to better support their grain load.

Genetic Traits: Certain genes regulate culm thickness and the length of internodes (stem segments). Thicker culms and optimal segment lengths provide greater mechanical support, making the plant less prone to bending or breaking. Genes that control the production of lignin, a key structural component in plant cell walls, contribute to culm strength. Higher lignin content increases rigidity and resistance to mechanical stress. Some rice varieties are naturally stronger due to the inheritance of favorable alleles for these traits.

Good Farming Practices: Maintaining healthy soil with adequate organic matter and nutrients

Methods to Improve Culm Strength

Over the years, significant efforts by scientists and farmers have revolutionized rice cultivation, particularly in addressing the issue of lodging. Starting from the Green Revolution to modern genomic tools, advancements in technology and research have greatly enhanced rice productivity and resilience.

Marker-Assisted Breeding (MAB): Scientists use molecular markers to identify genes associated with culm strength. This targeted approach allows for the selection of the best parent plants, significantly speeding up the breeding process.

Example: Selection for genes controlling thicker stems or higher lignin content.

The Role of Environment in Rice Culm Strength

Even with genetic improvements, environmental factors significantly influence rice plant performance, including their ability to resist lodging. The interplay between genetics and the environment highlights the need for an integrated approach to rice cultivation.

- **Heavy Rains or High Winds:** Extreme weather events can exert force on rice plants, causing even strong stems to bend or break.

supports overall plant vigor, including culm strength. Proper water management ensures that rice plants can access the nutrients they need for robust growth. Silica (Si) is a crucial nutrient that strengthens cell walls by depositing in the epidermal cells, making stems more rigid and resistant to bending. It also acts as a barrier, providing protection against diseases and pests that can weaken the stem. Farmers can use silicon-rich fertilizers or amend soils naturally high in silica. For example, adding rice husk ash, a byproduct of rice milling, is an effective and sustainable way to boost silica levels. A balanced application of nitrogen, phosphorus, potassium, and micronutrients like zinc and silica ensures strong plant growth while avoiding over-fertilization, which can lead to excessive plant height and increased lodging risk.

CRISPR and Gene Editing: Advanced tools like CRISPR enable precise modifications to the rice genome. Researchers can directly enhance the expression of genes involved in stem fortification, such as those regulating cellulose and lignin synthesis, to make the culm sturdier.

Genome-Wide Studies: Through large-scale studies, genes like *OsDWF4*, linked to stem strength, have been identified. These findings allow scientists to breed rice varieties tailored to withstand environmental challenges and reduce lodging risks.

- **Temperature Fluctuations:** Stress caused by heat or cold can weaken cell walls and reduce the plant's overall resilience.
- **Nutrient-Poor Soils:** A lack of essential minerals like silica, nitrogen, or potassium can impair the development of thick and sturdy stems.
- **Improper Farming Methods:** Practices such as over-irrigation or insufficient crop rotation can deplete soil nutrients and weaken plants over time.

Benefits of Stronger Culms

Improving culm strength provides a wide array of advantages that go beyond reducing lodging. These benefits impact not only farmers but also the broader agricultural and environmental landscape.

1. **Higher Yields:** Strong culms can support heavier panicles, allowing plants to produce more grains without collapsing. This increased yield is especially important for meeting the food demands of a growing global population.
2. **Better Grain Quality:** Upright plants are less prone to damage from soil moisture, pests, or diseases. This results in higher-quality grains with improved market value and better nutritional attributes.

Conclusion

As climate change brings more extreme weather, strong culms are becoming increasingly vital for rice farming, ensuring plants can withstand storms, heavy rains, and strong winds without lodging. Scientists are leveraging advanced technologies, such as CRISPR and genome-wide studies, alongside traditional breeding practices to develop climate-resilient rice varieties with enhanced

3. **Efficient Harvesting:** Standing crops are easier to harvest mechanically or manually. This reduces labor costs and time spent during harvest, making farming operations more efficient.
4. **Environmental Advantages:** Lodged plants often rot in the field, leading to wasted water, nutrients, and energy invested in cultivation. Stronger culms minimize this wastage, contributing to more sustainable farming practices. Reduced lodging also means fewer greenhouse gas emissions from rotting plant material.

Additionally, the straw from strong rice plants can be reused as animal feed, building material, or biofuel, adding more value to the crop.

stem strength. Farmers are complementing these advancements by adopting improved practices, like using silica-rich fertilizers and optimizing irrigation, to further reinforce plant stability. Together, these efforts aim to reduce crop losses, improve yields, and ensure rice remains a reliable food source for billions, making strong culms the unsung heroes of sustainable rice farming in a changing world.

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