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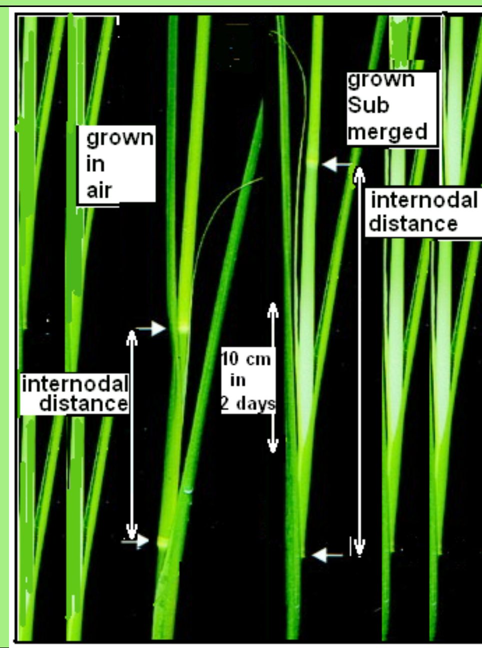
Rice grows fast as it sinks


Deepwater paddies in Bangladesh.
B. TAYLOR/HTTP://ANTBASE.ORG/ANTS/AFRICA/PERSONAL/DWR/DWRCOVER.HTM

The rice plant has adapted to keep its head above water, says S.Ananthanarayanan.

The rice plant differs from other cereal plants, like wheat or barley, in the way it saves its contact with air for efficient photosynthesis. The corrugated and water repellant surface of leaves and stalk of the rice plant, when submerged in water, is coated with a layer of air. This layer helps regulate the flow of carbon dioxide and oxygen, for the plant to use light energy to grow. Other plant varieties use this pathway to a much lesser extent.

Another important adaptation of some varieties of rice is the ability for incredibly fast growth during rising flood levels, to raise the uppermost leaves out of water and into contact with air. The growth can be up to 25 cm (3/4 of a foot) in a single day! Other, high yielding varieties of rice lack this ability and would flounder with rising water levels. Passing on the feature to other varieties has become important in the context of the need for steep increase in rice production in the next few decades.

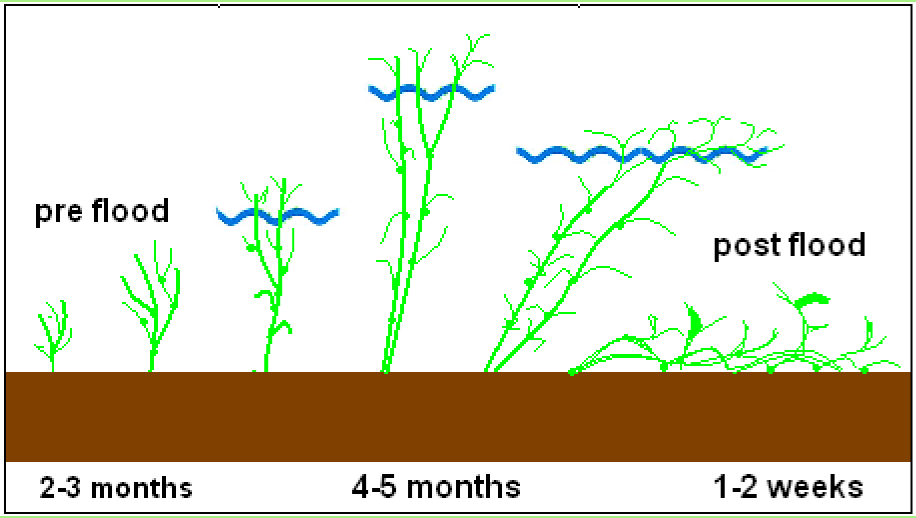


Motoyuki Ashikari at others at the Bioscience and Biotech Centre at Nagoya University, Japan report their discovery of the genetic bases of some strains of the rice plant's ability to elongate in rising water – and follow up with a means of grafting the feature on to the more productive but less hardy varieties

Deepwater rice

Rice feeds billions of people and its production has more than doubled since 1960. It is estimated that requirements by 2050 would require another doubling of production. But vast areas under rice cultivation are in rain or river fed areas where water levels can rise by several metres or where flash floods can submerge the crop for days on end.

In these areas only local varieties which are adapted to deep water can survive. In the traditional cultivation method, young plants are nurtured and allowed to stabilize before the water level rise begins. When water rises, the portion between the nodes in the plant stem rapidly elongate so that at least a few leaves are outside the water. While the top of the plant thrives and funnels gases to the stalk down below, additional roots sprout at the submerged nodes to help support the taller plant. When the flood recedes, the uppermost internodes begin throw shoots upwards and after the flood, the plant settles down with more roots going down and shoots going up.



The need to divert resources for building up the length of the internodal stem has perhaps limited the efforts to push up the productivity of such flood-resistant rice varieties. And while other varieties can be as much as 5 times as productive, there has not been notable success in making the productive varieties comparably hardy in real conditions of rice cultivation.

Genetic bases

The Nagoya University scientists have pinpointed three segments of deepwater rice chromosomes which are implicated in the stem elongation during flooding. When these regions were bred into a less hardy, high yielding strain, the new strain gained the ability to elongate. The scientists were then able to zero in on just two genes that clearly switched on underwater shoot elongation.

The two genes have been appropriately called SNORKEL1 and SNORKEL2, after the snorkel, which divers use to breathe when focusing underwater and the role that the elongated step plays in passing air down the stalk. Snorkel genes are activated by the volatile hormone, ethylene, which in turn, accumulates when the stem is partially submerged and ethylene cannot readily diffuse. There is then a chain of responses, which leads to the marked stem elongation.

Another gene that is in the same chromosomal region as Snorkel is the SUBMERGENCE group, which determines the response to complete submergence. This gene, which has the opposite effect of suppressing rapid stem elongation, was identified in a rice variety that is known for its ability to survive long periods of complete submergence. The SUB1,2,3 group, also activated by ethylene, helps the plant conserve vital carbohydrates, through limiting stem elongation, saving the resource for regeneration when the flood recedes.

The SK and SUB genes thus permit different strategies – the ESCAPE route, where the plant out grows rising waters and keeps its head dry – and the QUIESCENT mode, where the plant shuts down nutrient grabbing growth, to wait for conditions to normalize.

Practical use

Identifying the genetic bases for flood response of these adapted strains makes it practical to introduce the fast elongation trait into high yielding varieties. Such varieties can then be introduced in flood prone area – as a complement to successful development of SUB1 varieties, which provide robust submergence tolerance. Genetically modified strains cultivated in deep water may not match the output of shallow water paddies, because of the sharing of carbon between stalk elongation and grain output. But there is promise of improvement of output of farmlands with low yield but hardy rice plants.