CHALKY RICE

As higher temperatures affect rice quality around the world, researchers are developing DNA markers to produce more heat-tolerant varieties and stop rice grain turning to 'chalk'

BY GIO BRAIDOTTI

Rice that breaks or powders during milling due to a defect called 'chalk' affects growers across all socioeconomic scales—from villagers who grow rice for home consumption to large-scale farmers servicing export markets. The trait becomes more prevalent with high temperatures, a fact that leaves rice breeders in no doubt that climate change will bring quality and yield losses to rice growers unless counter-measures are developed.

The problem of chalky grain has been around for a long time and, despite considerable research, nobody has succeeded in breeding chalk out of rice. With a temperature rise of just 2° C sufficient to trigger the trait, researchers have noted that a 4° C increase could ruin entire crops, except for particular uses such as risotto, paella and sake.

In the past, research efforts focused on starch biochemistry, since loosely packed starch granules characterise chalky grain. But starting in 1997, Dr Melissa Fitzgerald, a Philippines-based researcher with close ties to the Australian rice industry, has overturned that conventional wisdom about chalk.

Dr Fitzgerald heads the Grain Quality, Nutrition and Postharvest Centre at the International Rice Research Institute (IRRI) in the Philippines. About 18 months ago, she had a 'scientific moment' during a seminar that helped her redefine chalk's underlying causes.

The seminar related to using a nitrogen isotope to trace where new growth occurs during rice development. The study found that during grain-filling, rice plants are able to switch resources away from making seed and into developing more stems or tillers.

"That means rice is not a true annual—it is actually a weak perennial," Dr Fitzgerald says. "I then realised chalk has nothing to do with how starch is made. Rather the panicle—the plant's branched flower-head where seed develops—has no control over the amount of time available to fill grain. There is a cut-off time. So what we call chalk is simply grain that did not mature in time."

This new perspective allowed Dr Fitzgerald to make sense of an earlier observation involving panicle architecture. Previously she had noted that panicles form primary branches during early stages of seed development and secondary branches later in development. Given that late-developing grain is more susceptible to the cut-off in seed production, Dr Fitzgerald suddenly understood why grain located on secondary branches is often much chalkier than on primary branches.

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"When I went to IRRI, I realised how much variability there is in panicle architecture in different rice varieties," she says. "There were varieties in the Philippines that were rarely chalky. When I looked at their panicles, they had very few secondary branches, indicating that panicle architecture is under genetic control and these genes play a role in chalk."

While this amounted to a new way of thinking about chalk, Dr Fitzgerald needed to connect the new mechanism to heat stress. Experiments quickly followed where she compared plants grown at 26° C and 33° C. She found that at the higher temperature, plants had only half as many days in which to make grain (14 compared with 30).

"Because of the shorter time available for grain-filling, there is more immature grain at higher temperatures, with immaturity expressing as chalk," she explains. "So overall, rice is a weak perennial with a limited amount of time devoted to grain production and that time is reduced by high temperature."

With the focus still on heat stress, she also found that different rice varieties, with different underlying tendencies to chalk, also mount different stress responses. At one extreme, the plant attempts to fill all grain, resulting in high yields of low-quality, chalky rice. At the other end, the plant sacrifices half the grain, resulting in low yields of high-quality grain. Variation in this stress response was also found to be under genetic control.

"The work immediately suggested a number of ways to reduce the occurrence of chalk," Dr Fitzgerald says. "What we need to do is minimise secondary branching in the panicle, extend the time available for grain-filling, and select for a heat-stress response that avoids chalking."

Towards that goal, Dr Fitzgerald's IRRI team is using ACIAR funds to map newly discovered genetic variation for chalk traits onto discrete regions of the rice genome. DNA markers can then be developed to facilitate selective-breeding efforts that could deliver rice varieties less prone to chalk at high temperature. ■

PARTNER COUNTRY: The Philippines

PROJECT: CIM/2006/176: Develop molecular markers for rice breeders to reduce the occurrence of low-quality 'chalky' grain

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