



# Global players

ACIAR is a conduit for delivering leading researchers and their knowledge to the sharp end of agriculture's struggle to keep food supply ahead of demand

BY BRAD COLLIS & DR GIO BRAIDOTTI

**E**very year when village rice farmers front up to their local mill their families' futures are on the line. Until the husk is removed from the grain its quality is unknown ... Will it be enough to feed the family for another year? ... Will it be suitable for sale in local or larger markets?

The main determining factor is the degree of 'chalkiness', a visual defect that indicates the presence of immature starch granules, which weaken the grain and make it prone to breaking during milling (polishing). If this happens, the amount of edible or tradeable grain is significantly reduced.

The defect is mainly caused by high temperatures during the rice plant's grain-fill period and, with mean temperatures likely to keep rising as climate change intensifies, there is a pressing need to find an answer.

Melissa Fitzgerald is an Australian scientist at the centre of this Philippines-based research. A specialist in rice quality, she worked initially to lift grain quality for Australian farmers, before transferring her skills to the International Rice Research Institute (IRRI), in the Philippines, five years ago.

Dr Fitzgerald was running the grain-quality laboratory at the NSW Department of Primary Industry's Yanco facility when she was invited

to set up, from scratch, a postharvest—grain quality and nutrition—centre at IRRI.

The offer was compelling for two reasons. It opened the door to making a direct contribution to poverty reduction and it also broadened her scientific scope. "In Australia the rice research was limited to Japonica, whereas IRRI works with just about every variety grown," she says. "Getting my hands into all that genetic diversity was a strong attraction."

Five years on, Dr Fitzgerald's team is starting to make real progress and she is confident IRRI will soon be able to supply breeders with the genetic tools to lower the risk of chalk. This will strengthen the climatic resilience of rice crops and contribute directly to the wellbeing of rice communities.

"In domestic markets, chalk can devalue the grain by up to 25% and in international markets by up to 30% or more," she explains. "But aside from the monetary value, chalk reduces the amount of edible grain a farmer will take home from the mill. So chalk has a huge impact and it is something we've never been able to eliminate by breeding—despite there being a genetic component to the trait."

Although some varieties are less prone to chalk, the trait doesn't reliably cross with conventional breeding (see breakout story). Nonetheless, the varieties that can avoid

chalkiness have shown researchers the path to follow. Dr Fitzgerald says the varieties that don't produce chalk when grown under the same heat-stress conditions as susceptible varieties have a self-regulating mechanism that responds to high temperatures by aborting the production of spikelets (flowers). So when stressed by high temperature the plants produce less grain, rather than partially filled or chalky grain.

For Dr Fitzgerald, there is enormous satisfaction in helping to drive an area of research that stands to make a large and measurable difference to potentially millions of smallholder farmers.

In fact, if a scientist can make a difference at IRRI they are helping nearly 2.5 billion people who depend on rice every day. It is a point noted by Professor Beth Woods, executive director for research and development strategy at Queensland Primary Industries and Fisheries (QPI&F), who was recently appointed chair of the IRRI board.

She sees IRRI at the cutting edge of poverty reduction and views her particular role as ensuring scientists on the ground are effectively equipped and directed.

It is her experience as a research manager and strategist that she injects into the system, and that complements the technical specialists on IRRI's board.



Cambodian farmers planting rice.



Popular Cambodian rice varieties. Rice is two to three years away from being a source of vitamin A.

PHOTOS: BRAD COLLIS

“My day job in Australia is thinking about the strategy and the effectiveness and efficiency of investment in R&D,” Professor Woods says. “QPI&F represents a direct research spend of more than A\$100 million or so a year, so I’m busy thinking about how you manage that—how you ensure you have the infrastructure to support high-priority R&D going forward ... So I’m ‘hands on’ in an R&D management role and that’s what I bring to the international system and to IRRI in particular.”

Professor Woods feels the task facing international agricultural research has just become a lot more complex following the double-hit of last year’s food crisis and the global financial crisis.

Because of the effect on food prices, she says an estimated 100 million people have been pushed back into the poverty they had only recently escaped. It means they are again reliant on commodity foods, such as rice, that don’t provide the nutritional diversity of fruit, vegetables and meat.

This has added to the urgency of incorporating nutrients such as vitamin A, zinc and iron into rice varieties.

Of these, pro-vitamin-A-enhanced rice (dubbed ‘Golden Rice’) is the most advanced. The first commercially available breeding material is now only two to three years away for rice growers

## Biotechnology boosts efforts to breed chalk out of rice

To the chagrin of breeders striving to improve rice yields for poor farmers, chalking is one of those traits where selective breeding simply does not work.

Despite scientists being able to detect the occasional non-chalking rice variety, Dr Melissa Fitzgerald says the trait simply does not breed true. “For years breeders were trying to recover the chalking tolerance trait, but they just could not do it by conventional means. Crosses between non-chalking lines typically produce plants with huge amounts of chalk when heat stressed.”

IRRI scientists have come up against this problem before. Previously the occasional landrace was detected that could survive flooding but, similarly, the trait could not be recovered by selective breeding. With flooding of rice lands causing estimated losses of A\$600 million a year, scientists found a way around the problem. At IRRI they mapped the trait against the rice genome, making it possible to develop molecular markers for the pieces of DNA responsible for submergence tolerance.

Dr Fitzgerald says those DNA markers made it possible to finally move the trait from a landrace to higher-yielding varieties. “Using markers, submergence tolerance was moved into popular rice varieties that are grown on millions of hectares. So that is exactly what we want to do with chalk.”

To make marker-assisted breeding possible, Dr Fitzgerald must identify precisely which bits of DNA in a non-chalking rice variety are required to inherit the trait. To detect that DNA, IRRI has selected two rice lines that are genetically similar except for chalking characteristics. This provides the maximum contrast needed to detect chalking genes.

The two lines were then crossed. During sexual reproduction, DNA is exchanged between the two genome types, causing the chalking variety to pick up bits and pieces of DNA from the non-chalking line. The progeny can then be screened for variation in their chalking response.

“From a starting population of 740 mapping lines, we selected 240 lines that can help us locate markers for the non-chalking trait,” Dr Fitzgerald says. “We have grown the lines for four generations and have some really reliable chalk data, including for lines that do not chalk at all at high temperatures.”

Dr Fitzgerald says that the first round of mapping produced five candidate DNA sites, one of which shows promising signs of having a regulatory role in grain filling during heat stress. The IRRI team is working on getting more markers to screen around that region.

“We will then look through gene banks to screen for genetic variation in that region and look at how it affects the non-chalking trait,” Dr Fitzgerald says. “That should place us in a strong position to develop markers that can help breeders select against chalk.”

– GIO BRAIDOTTI



Dr Craig Meisner (second from left) is leading ACIAR's CAVAC activities in Cambodia.



Melissa Fitzgerald, IRRI.

PHOTO: BRAD COLLIS

in the Philippines, but it will be another decade before the nutrient is likely to be commonly found in rice grown in the rest of the world.

It highlights the long timelines needed and the critical role played by the people who must plan and direct these long-term research efforts.

"Fortunately we do now have some technologies that will allow us to meet this challenge. Gene technologies, while neither quick nor cheap, will nonetheless offer us some technical opportunities that we've not had previously ... although when you compare the potential cost of addressing issues such as vitamin A deficiency, and also zinc and iron, through supplements, it's way ahead."

Professor Woods says one of her priorities at both QPI&F and IRRI is keeping infrastructure viable. "If you don't refresh infrastructure you limit what the science can do—and it's a critical question for an organisation like IRRI, which is coming up to its 50th anniversary and has a lot of old equipment and facilities."

Professor Woods is in a prime position to see the direct benefits of multilateral research partnerships and she is committed to activities delivering both development outcomes and domestic outcomes.

"For example, our Queensland scientists who are working on drought tolerance in sorghum are collaborating with IRRI scientists working on the same mechanisms in rice. As more of our science becomes molecular we are less tied to actual species and more interested in understanding the underlying mechanisms, which tend to be common or similar between species. So the work at IRRI on drought tolerance in rice is very relevant to the work in Queensland on sorghum drought tolerance."

Dr Craig Meisner, head of the ACIAR-managed research and extension arm of the AusAID-funded CAVAC (the Cambodia

Agricultural Value Chain Program), is another scientist who embodies the skill set that is deployed in multilateral research partnerships.

Dr Meisner is a US national and an adjunct professor at Cornell University, who worked for 25 years as an agricultural scientist in Bangladesh and now runs a project managed by ACIAR in Cambodia.

In Bangladesh, through the CGIAR system—primarily CIMMYT's Bangladesh outreach station—Dr Meisner took an otherwise fallow dry season and, by using groundwater, helped farmers extend the growing season. The introduction of high-yielding maize, rice and wheat varieties resulted in a food production boom that transformed farms from subsistence poverty-traps into entrepreneurial businesses. In the process, rural economies were developed to service this vastly more complex and intensive farming system where householders have access to irrigation and are able to invest in farm machinery and soil nutrients.

"Bangladesh was a situation where improved productivity could, in fact, result in improved profitability," Dr Meisner says. "That is not always the case—each country is different. But because of the high population density, Bangladesh has an immediate, immense need for food. That domestic demand means that the more productive the farm, the more profitable it is."

In 2009, Dr Meisner moved to Cambodia to the AusAID-funded CAVAC program, which is even more ambitious than his work in Bangladesh.

Dr Meisner was familiar with ACIAR, having partnered ACIAR projects in Bangladesh, and has worked with so many Australians that he considers himself an 'honorary Aussie'. He was attracted to CAVAC by its holistic approach and willingness to embrace the entire food-production chain, going beyond the mandate of individual R&D organisations to include

farm machinery, supply importers, market development, exporters, training and business development.

"I am interested in pursuing a broad R&D approach that follows growers' needs throughout the development arc from subsistence farming to entrepreneurial systems," he says. "The opportunity to work at precisely this holistic level came up when Australia's long-standing agricultural development efforts in Cambodia matured into the CAVAC program. For me, it amounted to the dream job."

In addition to Dr Meisner's component, CAVAC intends to have components looking at irrigation, agribusiness and policy development. Dr Meisner finds this approach "freeing" and sees it as the right synergy to positively lift rural communities in the three participating Cambodian provinces of Kampong Thom, Takeo and Kampot.

"In many ways Cambodia is currently where Bangladesh was in 1980—on the threshold of harnessing the potential of irrigated dry-season cropping options," he says. "There is a dynamism emerging in the country and we are trying to capture the need for knowledge so that farmers can ride that wave."

He says CAVAC amounts to the logical progression of the best that agricultural development has to offer. The goal is to see a dramatic change in the options available to growers so that the opportunity to make more entrepreneurial decisions becomes more widely available.

"Frankly, I think many donors in Cambodia are looking to this as the most innovative agricultural program ever initiated by AusAID. Its potential is quite strong. Because you can work with the whole value chain, you can broaden the scope of what can be achieved. We want it to stand as a model for future projects." ■