Yesterday's aid recipient is today's R&D partner

As increasing demand for grain challenges drought and flood-afflicted farmers worldwide, a partnership between India and Australia is allowing agricultural scientists to share germplasm, funds and breeding expertise to help farmers lift wheat productivity.

David Deery manning the 15-metre imaging tower of Australia's High Resolution Plant Phenomics Centre, which is used to take infrared thermography images of wheat crops. The imaging technology is used to improve the water productivity of wheat in dryland farming systems.

PHOTO: ANTON WASSON

KEY POINTS:

- **Indian and Australian researchers are exchanging wheat germplasm to raise the resilience and productivity of both countries' wheat crops.**
- **The program targets both breeding and agronomic practices such as conservation agriculture.**
- **Unique germplasm has been identified, with far-reaching implications for improving water productivity in dry farming regions.**

BY GIO BRAIDOTTI

There is a longstanding debt Australia owes India when it comes to its farmers' ability to produce vast surpluses of bread wheat. Pedigrees reveal that crosses made in the 1890s introduced genes from an Indian landrace into Australian wheat that proved so advantageous that they persist in elite varieties to the present day.

Researchers now believe that encoded in the Indian DNA are valuable stress-tolerance genes—to saline soils, for example—that help wheat adapt to the harsh environments of much of the Australian wheatbelt.

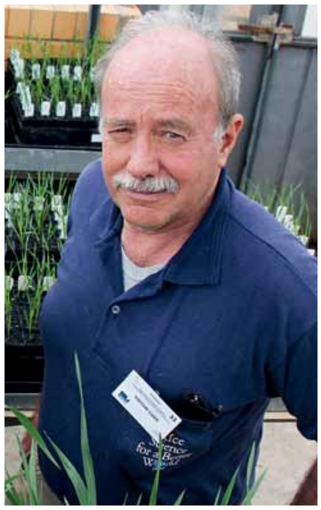
To Dr Paul Fox, manager of ACIAR's Crop Improvement and Management program, the Australian success of Indian biodiversity indicates just how similar the agro-climatic landscapes and cereal-production challenges are in the two countries.

In recognition of this similarity and its food security implications, ACIAR has sponsored agricultural science collaborations between the two countries since 1983. As India developed, however, the relationship matured and it now jointly funds ambitious research projects in key crop-production challenges of the 21st century.

Prime among these are efforts to overcome major wheat-yield constraints arising from water scarcity and poor or hostile soils.

"The relationship with India is a big positive for Australia and consists of 12 projects, worth $22 million, focusing on four areas: wheat breeding, cropping systems, water management and agricultural policy," Dr Fox says. "It is also a significant evolution in the relationship for both countries."

Dr Michelle Watt PHOTO: BRAD COLLIS



Dr Howard Eagles PHOTO: FELICITY PRITCHARD

Dr Paul Fox PHOTO: EVAN COLLIS

FAMILIARITY BREEDS BETTER WHEAT

Active within the Indo–Australian wheat-breeding research network is Dr Howard Eagles of the University of Adelaide. Dr Eagles' familiarity with the pedigree and provenance of important wheat traits is so extensive that it advances molecular genetics, bioinformatics and commercial breeding.

He has recently finished work on an ACIAR project that provided Indian breeders with Australian germplasm and DNA markers to develop biscuit-quality wheat varieties. India is the second-largest biscuit-consuming country in the world (after the US), but relies on enzyme-treating flour from chapati wheat to make biscuits.

"The intertwining of Australia's gene pool with India's has an interesting history," Dr Eagles says. "It was legendary Australian wheat breeder William Farrer who first acquired Indian wheats and corresponded with Indian breeders."

The parentage of Federation wheat unequivocally includes an Indian landrace, 'Etawah', named after a district in the state of Uttar Pradesh. Genes originating from Etawah are now thought to have contributed a lot of stress tolerance to Farrer's wheat varieties.

"Federation basically created the current Australian wheatbelt because it could grow inland in dry areas," Dr Eagles says. "Farrer essentially figured out Mendelian inheritance and in 1895, during a tremendous drought, he spotted and selected a few lines from his crosses with Indian, Italian and Canadian wheats that coped a fair bit better. That was the start of Federation."

With a long history of growing wheat in low-rainfall seasons, Australia has kept up Farrer's legacy and possesses some of the world's best scientists when it comes to providing wheat with the means to yield in hot, dry conditions.

Prime among them are the CSIRO Plant Industry team headed by Dr Richard Richards. In 2009, Dr Richards' team decided to join the Indo–Australian Program on Marker-Assisted Wheat Breeding and the development of their latest suite of water-productivity traits is now partially funded by ACIAR. Heading the ACIAR-related activities is Dr Michelle Watt.

"CSIRO's philosophy is that to improve productivity in water-limited conditions is to essentially adapt the architecture of the wheat plant—the shoots and roots—to better scavenge and make use of available water," Dr Watt says.

"In significant zones of both Australia and India, wheat has to rely heavily on moisture stored in the soil for growth, supplemented only by low rainfall in Australia and limited irrigation from unsustainable groundwater sources in India."

The CSIRO team has made its most advanced wheat lines available to India as part of a germplasm exchange with breeders at the Directorate of Wheat Research, the Indian Agricultural Research Institute and the Agharkar Research Institute.

In a departure from past funding arrangements, the Indian partners do not receive ACIAR funds but are independently supported by the Indian Council of Agricultural Research.

ADAPTING TO HOTTER, DRIER CLIMATES

The CSIRO wheats are unique, the product of assimilating years of experience on how best to improve wheat yields in water-constrained farming systems.

Dr Watt says the CSIRO wheats have been field-tested in Australia and are especially advantageous in no-till farming systems where stubble from the previous crop is retained to increase water infiltration to the soil and improve soil structure.

In exchange, CSIRO has received a package of 40 Indian wheat lines, selected for their standout performance in dry areas. Among that material is 'Lok1', a variety developed by an Indian philanthropic organisation.

"Lok1 was first released in the 1970s but is still grown by Indian farmers because it performs so well in the really dry central and peninsular areas," Dr Watt says. "We suspect there might be something special about its roots and we look forward to examining what makes this line perform well with little water. That's just one of the lines the Indian researchers provided for the project."

All the wheat lines are due to be assessed for water productivity side-by-side in India and Australia.

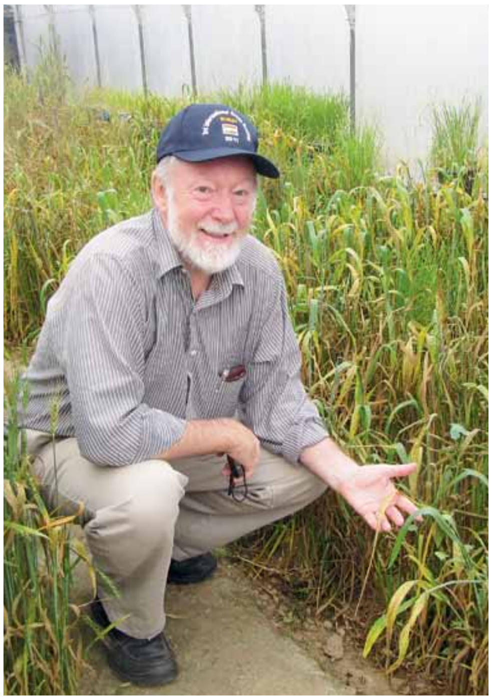
MORE PRODUCTIVE FARMING

Agricultural scientists such as Dr Watt realise that yield gains are not achieved through genetics alone. In Australia over the past 30 years, 70% of wheat yield gains have been attributed to advances in agronomy. Prime among the beneficial new farming techniques are stubble retention and reduced tillage, techniques that fall under the umbrella of conservation farming.

"We do have in mind that the CSIRO wheats are advantageous in no-till, stubble-retained farming systems," Dr Watt says. "Our research showed that was the case in Australia. So it is very likely that we might try to combine water-conserving agriculture with this germplasm in 2012 within the Indian trials."

Conservation farming replaces stubble burning and ploughing, which tend to damage soil structure and aggravate loss of soil moisture and fertility. In India, however, existing farming

Dr Gurjeet Gill



Dr John Dixon

practices add an extra complication. In some parts of India, wheat is planted in rotation with rice. Dr Gurjeet Gill from the University of Adelaide explains that soil degradation is common in rice–wheat systems, caused by excessive tillage and 'puddling' of soil (to minimise water infiltration) in flooded fields for paddy rice production.

"This aggressive tillage for rice production creates an inhospitable soil environment for the following wheat crop," Dr Gill says.

Since 2006, Dr Gill has headed an ACIAR project that developed a no-till rice-production system to complement no-till systems for wheat developed and introduced in past ACIAR research. He collaborated with Chaudhary Charan Singh (CCS) Haryana Agricultural University, Punjab Agricultural University and the International Maize and Wheat Improvement Center (CIMMYT) in India. The project is active in India's north-western plains zone of Punjab and Haryana, as well as the eastern state of Bihar.

The result is a mechanised double no-till system that produces similar rice yields while using up to 30% less irrigation water and less labour. As a bonus, soil structure is not degraded during the rice rotation, which allows for 10% higher wheat yields.

"With double no-till, farmers can retain stubble and go in with a drill to sow the next crop," Dr Gill says. "In most cases, crop residues are removed from the fields and used as animal feed in an integrated cropping-livestock system.

"We found that traditional varieties perform well in the double no-till system. Hybrid rice does particularly well, as does Basmati rice."

Locally made seed drills have been shown to perform well and do away with the need to hand transplant rice seedlings from the nursery to the field—an immensely hard job performed at above 35°C and 80% humidity. Farmers have also been encouraged to perform laser levelling of their fields before sowing to ensure even water distribution.

These innovations stand to have long-term beneficial effects on food-production resilience and farm profitability by helping to conserve oversubscribed water resources, especially declining groundwater, improve soil fertility and eliminate the need to burn straw. There is an additional and rather surprising economic impact as well.

"As wages rise in India due to industrialisation, farmers' labour costs have quadrupled in recent years," Dr Gill says. "Despite India being densely populated, farmers are facing declining access to labour and, with it, a decline in production. Double no-till helps reverse that trend."

Dr John Dixon, who manages ACIAR's Cropping Systems and Economics research program, says another important outcome of ACIAR's involvement in India has been growth in capacity within the Indian agricultural R&D sector.

"We've built the capacity in India to roll out conservation farming to interested farmers," he says. "In so doing, India is now in a position to help other countries, like Pakistan, to adopt no-till and reap the benefits as once Australia helped India." ■

PARTNER COUNTRY
INDIA

PROJECT: Indo–Australian Program on Marker-Assisted Wheat Breeding

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Deeper roots: the 'Holy Grail'

Working side-by-side, Australian and Indian wheat researchers are extending the search for improved productivity underground—to the root system.

"With regards to roots and improved water-scavenging traits, researchers worldwide have barely begun to make discoveries," Dr Watt says. "Almost all the research we are doing is new, so there are many opportunities for making important discoveries and that has created quite a keen atmosphere within the project."

Critical to these efforts are three field sites in India that provide near-ideal conditions to screen for diversity in root architecture. The trial sites are located in the central and peninsular states, where wheat is grown entirely on soil-stored moisture acquired during the monsoon. Without rainfall to confuse the results, wheat lines whose roots are best suited to scavenging moisture deeper in the soil profile as the season progresses can be identified.

The quest for deeper roots is an ambitious one—something of a 'Holy Grail' among wheat breeders. Dr Watt explains that impressive yield gains are thought to be possible with roots that are just 10 centimetres deeper at the time of flowering and seed setting.

"We have calculated that the uptake of an extra 10 millimetres of water can contribute to an extra half tonne of grain per hectare," she says. "So the deep-root trait has very high water productivity: a high yield per water available to the crop."

Coring to measure root architecture and soil moisture commenced in 2010 and the preliminary analysis indicates the existence of a lot of genetic variability—both in root depth and distribution—in the pool of Indian and Australian wheats.

"I think we will get that extra root length," Dr Watt says. "We easily have an extra 10 cm within the genetic variation in root system depth … in fact, we have up to 40 cm."

The next major challenge is making the selection process simpler on behalf of breeders, replacing soil coring with simple proxy measurements based on above-ground shoot traits.

"No-one in the world has yet managed to develop a reliable proxy test for deeper roots, but I think we can do it," she says. "That is the great advantage of working in these Indian environments. We can clearly see the wheat's ability to access deep soil moisture. So I do feel optimistic this project can eventually help farmers."