in the plant or canopy temperature is monitored by the CTS and used to inform the timing of irrigations.

Canopy Temperature Sensors and the thresholds to trigger irrigations are now commercially available to growers through Goanna Ag as part of its GoField Plus irrigation management system incorporating CTS and soil moisture probe. Although the algorithms only use canopy temperature and weather data to trigger an irrigation, it is equally important to monitor soil moisture using capacitance probes.

It means you are measuring what is going on under the ground as well as in the crop itself. Canopy temperature tells us when to apply an irrigation and moisture sensors indicate how much water might be needed to complete an irrigation. Sometimes we also see a stress signal in crop canopy temperature for other reasons, such as disease. In those situations, soil moisture data helps determine that an irrigation will not be beneficial to the crop.

The current SIP2 project is refining these technologies and working closely with Goanna Ag to streamline the process of providing growers the actionable data in real time. Critical to the adoption of the technology is to ensure the technology is both practical and reliable at a commercial scale. Collection of data from commercial cotton farms is ongoing and is being utilised to help better understand how CTS can be most effectively used to improve water use efficiency and productivity for fully irrigated and also for partially irrigated cotton.

There is ongoing testing of CSIRO's canopy temperature predictive algorithms platform for scheduling irrigations in advance, and continuing investigation of spatial variability of canopy temperature on larger commercial farms to determine the minimum number of canopy sensors required for effective and efficient irrigation scheduling.

There is quite significant potential for the CTS in limited water situations because CTS offer a quantifiable means of assessing crop stress. The impact of water stress on yield is affected by crop development. Canopy temperature is a function of day degrees (radiation) and water stress, which together determine crop development stage.

Trials conducted at CSIRO Narrabri using canopy temperature sensors showed peak flowering as the best time to apply an irrigation when water is available for a single irrigation only. The timing of this single irrigation can likely be optimised by considering both the crop development stage and the accumulated stress. This is currently being validated through on-farm trials in different valleys in collaboration with the CottonInfo team.

Canopy temperature sensors can aid in decision making and ultimately assist in optimising both fully irrigated and limited water cropping systems.

For more information, webinars and videos visit:

https://smarterirrigation.com.au/precise-real-time-automated-cotton-and-dairy-irrigation-for-improved-water-productivity/

https://smarterirrigation.com.au/joseph-foley-talks-about-automation-of-large-scale-irrigation/

https://smarterirrigation.com.au/andrew-greste-talks-about-precise-real-time-automated-cotton-and-dairy-irrigation-for-improved-water-productivity/

https://smarterirrigation.com.au/plant-based-sensing-for-cotton-irrigation-2/

https://smarterirrigation.com.au/canopy-temperature-sensors-as-an-irrigation-tool-by-cottoninfo/

https://smarterirrigation.com.au/plant-based-sensing-optimising-irrigation-timing-in-limited-water/

https://smarterirrigation.com.au/responsive-irrigation-management-with-canopy-temperature-stress-technology/

For more information on the Smarter Irrigation for Profit 2 program visit the website: *https://smarterirrigation.com.au/*

Hotter, drier, CRISPR: Editing for climate change

GENE editing technology will play a vital role in climate-proofing future crops to protect global food supplies, according to scientists at The University of Queensland.

Biotechnologist Dr Karen Massel from UQ's Centre for Crop Science has published a review of gene editing technologies such as CRISPR-Cas9 to safeguard food security in farming systems under stress from extreme and variable climate conditions.

"Farmers have been manipulating the DNA of plants using conventional breeding technologies for millennia, and now with new gene-editing technologies, we can do this with unprecedented safety, precision and speed," Karen said.

"This type of gene editing mimics the way cells repair in nature."

Her review recommended integrating CRISPR-Cas9 genome editing into modern breeding programs for crop improvement in cereals.

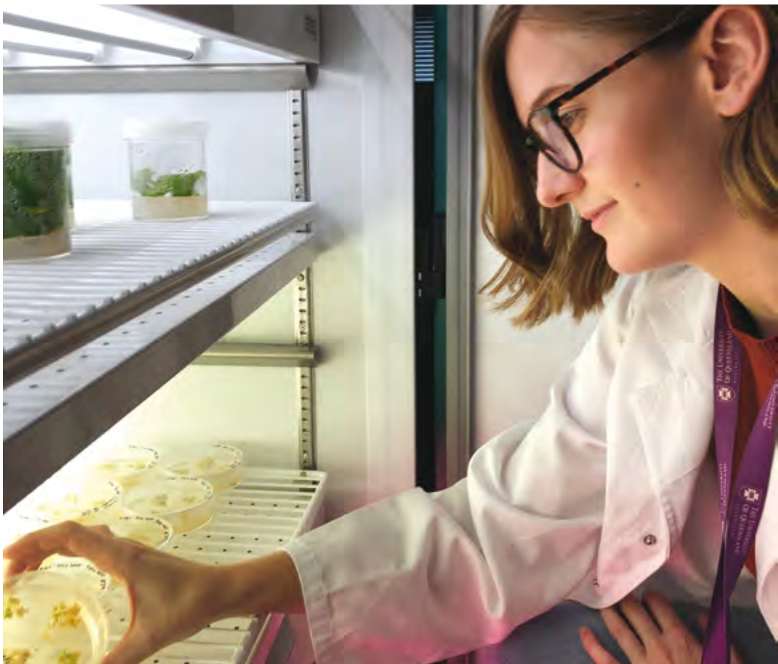
Energy-rich cereal crops such as wheat, rice, maize and sorghum provide two-thirds of the world's food energy intake.

"Just 15 plant crops provide 90 per cent of the world's food calories," Karen said.

"It's a race between a changing climate and plant breeders' ability to produce crops with genetic resilience that grow well in adverse conditions and have enriched nutritional qualities.

"The problem is that it takes too long for breeders to detect and make that genetic diversity available to farmers, with a breeding cycle averaging about 15 years for cereal crops.

"Plus CRISPR allows us to do things we can't do through



Dr Karen Massel from UQ's Centre for Crop Science.

Inspecting some of the gene-edited plants.

conventional breeding in terms of generating novel diversity and improving breeding for desirable traits."

In proof-of-concept studies, Karen and colleagues at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) applied gene editing technology to sorghum and barley pre-breeding programs.

"In sorghum, we edited the plant's genes to unlock the level of the available protein and to boost its nutritional value for humans and livestock," she said.

"We've also used gene-editing to modify the canopy architecture and root architecture of both sorghum and barley, to improve water use efficiency."

Karen's research also compared the different genome sequences of cereals – including wild variants and ancestors of modern cereals – to differences in crop performance in different climates and under different kinds of stresses.

"Wild varieties of production crops serve as a reservoir of genetic diversity, which is especially valuable when it comes to climate resilience," she said.

"We are looking for genes or gene networks that will improve resilience in adverse growing climates.

"Once a viable gene variant is identified, the trick is to re-create it directly in high-performing cultivated crops without disrupting the delicate balance of genetics related to production traits.

"These kinds of changes can be so subtle that they are indistinguishable from the naturally occurring variants that inspired them."

In 2019, Australia's Office of the Gene Technology Regulator deregulated gene-editing, differentiating it from genetically modified organism (GMO) technology.

Gene edited crops are not yet grown in Australia, but biosecurity and safety risk assessments of the technology are currently being undertaken.

This research is funded by an Australian Research Council Discovery grant with support from the Queensland Department of Agriculture and Fisheries and The University of Queensland.

This research is published in Theoretical and Applied Genetics (DOI: 10.1007/s00122-020-03764-0).

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