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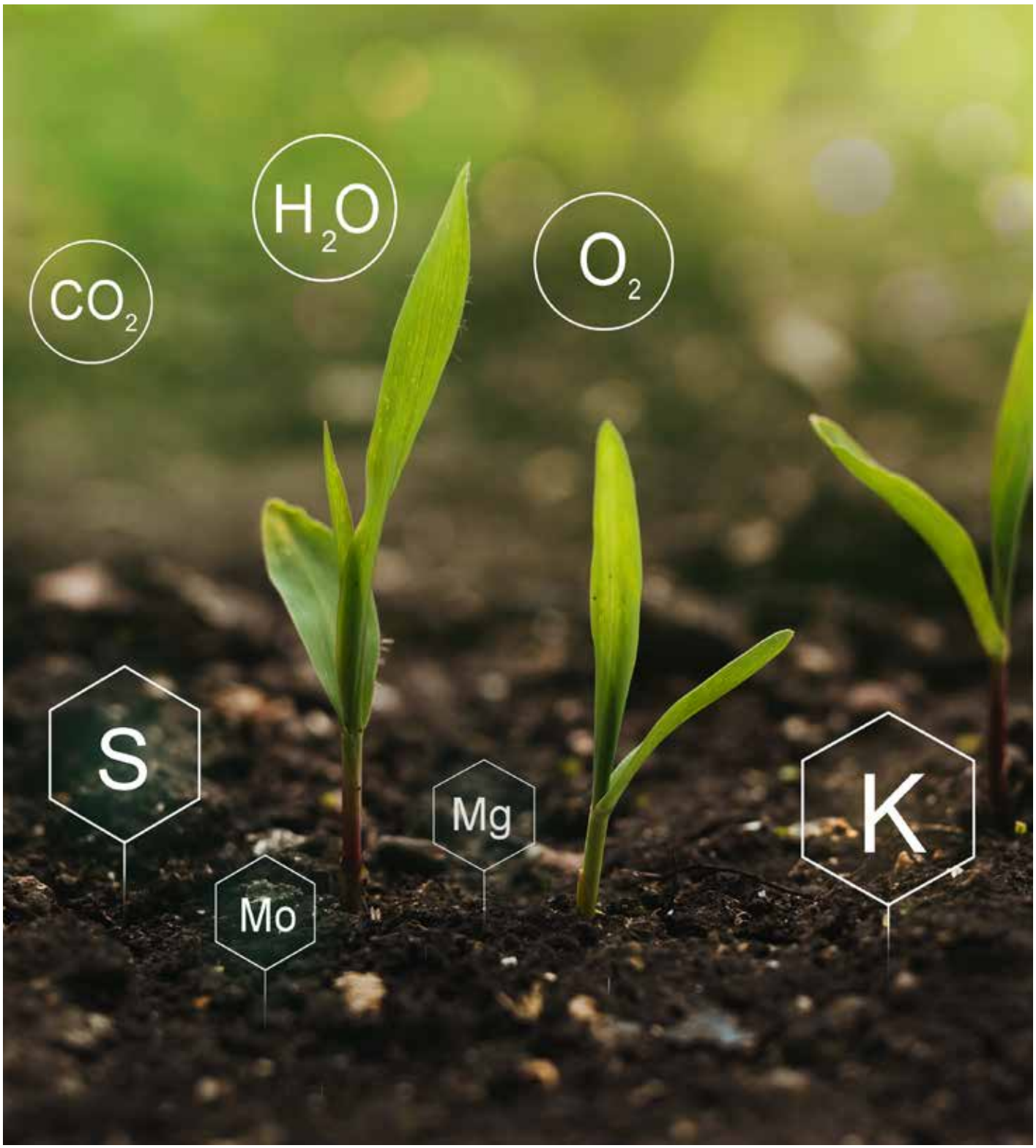
WINTER 2021 ISSUE 25

THE AUSTRALIAN AGRONOMIST MAGAZINE

Mix up your approach to fenceline weeds

Designer root systems to maintain durum wheat yields in drought

Better, faster, smarter crop variety data for nation's grain growers



Controlling Green peach aphid in canola

With most cropping areas across Australia experiencing a wetter summer this year, and the forecast of further rains ahead, many canola growers are looking forward to another bumper crop in 2021.

While the weather outlook is positive, Corteva technical specialist Chris Brown says that growers should bear in mind that the wetter conditions are likely to create a 'green bridge' of weeds that harbour insect pests such as green peach aphids (GPA). GPA will persist over-summer on a variety of hosts, including wild radish, turnips, mustard, volunteer canola and many other broadleaf weeds.

Green peach aphid is the most important vector of turnip yellows virus (TuYV) (96% transmission efficiency) but cabbage aphid can also transmit it (14% transmission efficiency), as can cowpea aphid. Certain strains of TuYV can infect pulse crops in southern Western Australia, New South Wales and South Australia, while other strains are canola specific.

Chris advises that "*Canola is most susceptible to TuYV up to the rosette stage, and infections at this point can lead to significant yield losses. Infections after the rosette stage generally have less economic impact but yield losses are likely up to approximately the mid-podding stage. Infection after mid-podding usually results in minimal yield loss, although oil quality can be affected.*"

Compounding these issues is the increasing presence of insecticide resistance in many GPA populations. Ongoing GPA research by Cesar Australia is finding high levels of resistance to carbamates (e.g. pirimicarb) and pyrethroids across Australia. Resistance to organophosphates and neonicotinoids (e.g. imidacloprid) have also been observed in many populations.

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Isoclast® active

INSECTICIDE

Transform® WG insecticide containing Isoclast® active remains the most effective post emergent treatment for GPA. Growers are encouraged to integrate chemical controls with cultural and biological controls to help manage and prevent further resistance issues. Understanding how Transform works and adhering strictly to the resistance management strategy for Transform will help delay GPA resistance to this insecticide.

Best management practices for controlling GPA and TuYV include eliminating the green bridge in and around the target paddocks a minimum of 14 days before sowing. Where possible, sow into standing stubble as aphids tend to fly into crops when they see plants against the backdrop of exposed earth; they are more attracted to open rows of plants with bare earth visible between crop rows. Selecting hybrid varieties that achieve early crop establishment and canopy closure can also help reduce aphid pressure.

Where the risk of aphid pressure is high, a seed treatment can be considered. Neonicotonoid based seed treatments can provide adequate protection early however, duration of control is dependent on seasonal conditions. In years where germination is delayed due to a late break the activity of these treatments may be reduced. In such cases, seed treatments can fail to provide adequate control up to the critical rosette growth stage. Vigilant crop monitoring will determine if or when a foliar insecticide application is warranted.

Sensitivity shifts to Transform have recently been found in a small number of GPA populations in Western Australia, showing the potential for low-level resistance evolution to this active ingredient. For now, Transform remains an effective foliar-applied insecticide for GPA control in Australia.

A sustainable long-term strategy for the control of GPA needs to be considered to manage the resistance risk by integrating selective chemical controls with practical cultural and biological controls.

Where monitoring indicates that chemical intervention is required, A soft, selective product such as Transform WG Insecticide will provide effective control of GPA while having low impact on beneficial insects leaving them free to help control later season pest outbreaks such as Diamondback moth.

Like all insecticides, Transform WG should be used only at the recommended label rates and according to the labelled resistance management strategy. Ensure spray applications achieve good coverage by using correct nozzles, high water volumes and appropriate ground speeds. Correct application will help prolong the useful life of this very important GPA / TuYV control option.

Chris Brown
Technical Specialist
Corteva Agriscience

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DESIGNER ROOT SYSTEMS TO MAINTAIN DURUM WHEAT YIELDS IN DROUGHT

TO HELP MEET STRONG INTERNATIONAL DEMAND FOR AUSTRALIA'S PREMIUM DURUM WHEAT, NEW RESEARCH HAS IDENTIFIED GENETIC SOLUTIONS TO MAINTAIN YIELDS DURING DROUGHT.

Queensland research has identified two genes that improve durum wheat yields under drought conditions. The research focusses on the architecture of plant roots and how it contributes to yield stability.

Dr Samir Alahmad, at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) has discovered the genes while investigating the traits that durum wheat uses to survive in water-limited conditions.

Dr Alahmad is a previous recipient of Monsanto's Beachell-Borlaug International Scholarship. His current research is part of a postdoctoral fellowship funded by the Grains Research and Development Corporation.

Root system architecture for durum variety DBA Aurora (left) versus an experimental line carrying the gene for narrow root angle. (Photo: Lee Hickey ©QAAFI)

"In dry seasons like 2018 and 2019, farmers suffered significant losses due to reduced grain quality and yield," Dr Alahmad says.

Dr Samir Alahmad holds one of the new experimental lines with diverse root traits. The new lines will be evaluated in 2021 to determine the value of the root traits to support yield in key durum growing regions. Photo taken at the Queensland Department of Agriculture and Fisheries Hermitage research facility near Warwick in Queensland. (Photo: Lee Hickey ©QAAFI)

Stabilising yields and quality for the crop in a variable climate is an ongoing challenge for growers, while maintaining supply to international markets. More than 80 per cent of Australian durum wheat exports go to Italy, where it is used for pasta production.

The first step in Dr Alahmad's research was establishing links with durum breeder Dr Filippo Bassi at the International Center for Agricultural Research in Dry Areas (ICARDA) to source elite durum lines that were originally bred for very dry conditions in Syria.

Dr Samir Alahmad inspecting the roots of an experimental durum line carrying the narrow root angle gene on chromosome 6A. (Photo: Lee Hickey ©QAAFI)

Collaborating with Professor Jason Able at the University of Adelaide, Dr Alahmad then crossed the ICARDA lines with the leading Australian durum wheats DBA Aurora and Jandaroi, subsequently developing a large experimental population to study their traits.

"You need six generations to develop genetically stable lines that are suitable for evaluation," Dr Alahmad says. "I used speed breeding technology, which involves growing plants under optimal light and temperature conditions, to reduce generation time, and refined the population in just one year."

The next step was to study the durum wheat population for root growth angle using transparent garden pots.

Dr Samir Alahmad holds one of the new experimental lines with diverse root traits. The new lines will be evaluated in 2021 to determine the value of the root traits to support yield in key durum growing regions. Photo taken at the Queensland Department of Agriculture and Fisheries Hermitage research facility near Warwick in Queensland. (Photo: Lee Hickey ©QAAFI)

Dr Alahmad matched this information with DNA marker data to perform a genome-wide association analysis. The result was the discovery of a major gene located on chromosome 6A in durum wheat.

Over the following two seasons he set up field trials in Queensland, South Australia and Morocco to better understand the value of the gene in improving yields under different drought conditions.

“We found there was an association between the root angle gene and grain yield,” he says. “In Queensland, root angle appeared to be important for maximising the length of the grain-filling period.”

Root system architecture for durum variety DBA Aurora (left) versus an experimental line carrying the gene for narrow root angle. (Photo: Lee Hickey ©QAAFI)

In another genome-wide association analysis, the location of the gene responsible for high-root biomass was identified on chromosome 6B.

“One of the most exciting aspects of the research was discovering that combining the root angle and root biomass qualitative trait loci resulted in a yield benefit of up to 0.9 tonnes per hectare under drought conditions,” he says.

Dr Samir Alahmad inspecting the roots of an experimental durum line carrying the narrow root angle gene on chromosome 6A. (Photo: Lee Hickey ©QAAFI)

However, more insight is needed to determine how much root branching is beneficial at different soil depths to sustain grain yields in different environments. Another challenge is understanding the complex interactions between root and canopy traits that influence the timing of water use.

Now, Dr Alahmad’s postdoctoral research is focused on developing elite durum wheat lines with similar above-ground traits that comprise different root configurations.

“These materials will enable us to more precisely determine the role of root traits to support yield under different drought scenarios.”

During 2020, seed of the elite lines with diverse root traits was bulked up at Hermitage Research Station, Warwick, Queensland. In 2021, field trials will be set up in Queensland and South Australia.

To take the research to the next level, Dr Alahmad is using unmanned aerial vehicles (UAV) to look at the effect of above-ground traits on drought tolerance.

“We will use this knowledge about the above-ground traits to better understand the value of root traits and the link between root and shoot dynamics,” he says.

“We want to help wheat breeders design future crops for farmers that provide more stable yields across seasons despite variable rainfall.

“In the next 12 months we will try to understand the traits that sustain grain yield in different seasons.”

This research is funded by the Grains Research and Development Corporation, Queensland Department of Agriculture and Fisheries and The University of Queensland.

Journal Reference:
Originally published in GRDC’s GroundCover Issue 151, March-April 2021, Written by Nicole Baxter, Published online 30 January 2021.

MIX UP YOUR APPROACH TO FENCELINE WEEDS

The recent discovery of multi-resistant capeweed along fencelines in Western Australia has put a fine point on the need for integrated weed management tactics to be applied to non-production areas on farms.

Glyphosate has been the go-to product for keeping weeds in these areas under control for a long time but unfortunately it is often the only product used and the weeds are commonly quite large when they are sprayed. The result is that glyphosate resistance can, and does, quietly build up in these zones in a wide variety of weed species.

Fencelines will always be a potential source of weed seed but there are ways to ensure that the seed from these areas is not already resistant to the herbicides when it blows into the production areas.

Farmanco agronomist, Brent Pritchard, collected the suspect capeweed samples on a farm near Borden in Western Australia. The capeweed had evolved resistance to glyphosate in an un-cropped drainage area, where it had routinely been sprayed with glyphosate, and had then invaded the adjacent field. The cropped area had been managed with a diverse rotation of wheat, TT canola, pasture and fallow over a 17-year period.

The capeweed samples also showed signs of resistance to metosulam (Eclipse®) and diflufenican (Brodal®), but were susceptible to a range of other herbicides including clopyralid, MCPA, bromoxynil, diuron, metribuzin, simazine, Spray. Seed® and Velocity®.

Dr Yaseen Khalil, a researcher in the agronomy team at the Australian Herbicide Resistance Initiative (AHRI), conducted the resistance screening and confirmed the resistance status of the capeweed population.

“There is no doubt that an integrated approach to weed management needs to be applied to non-production areas such as fencelines, around buildings, along tracks and roads and around irrigation infrastructure,” says Dr Khalil.

“Probably the first step is to stop using glyphosate alone in these areas unless you are able to reliably apply a double knock to every application. Evolving resistance to this useful herbicide in non-productive zones is counter productive at the least.”

Wherever possible, apply glyphosate in a mix with other herbicides effective on the target weeds, then follow with a second knock.

The main problem on fencelines is the lack of competition to weeds. If pastures are part of the crop rotation it may be possible to establish the pasture species along the fenceline and leave them in place when the paddock returns to the cropping phase. Similarly, the crop can often be sown right up to the fence and the first round or two mown or baled for hay prior to harvest. If there are livestock in the production system they can be used to graze the perimeter in the fallow or in suitable crops.

AHRI's Dr Yaseen Khlil confirmed the resistance status of the capeweed samples and is urging growers to take a more diverse approach to weed management in non-cropped areas around the farm.

Establishing cover using desirable perennial species and eliminating fenceline spraying could be a long-term solution to stop fencelines being a source of herbicide resistant weeds.

If this is not practical, or if the non-crop area must be kept bare for other reasons, such as managing insect pests, close attention must be paid to using alternative herbicides, double knocking, mixing and rotating herbicides and eliminating survivors.

Applying the WeedSmart Big 6 tactics to non-crop areas is a pre-emptive strike on ‘home-grown’ herbicide resistance.

For more information about managing herbicide resistance in weeds visit the WeedSmart website: www.weedsmart.org.au

Journal Reference:
Cindy Benjamin, WeedSmart

STUDY OF CHILLI GENETICS COULD LEAD TO GREATER VARIETY ON OUR PLATES

Scientists investigating the genetics of chilli pepper species have discovered a whole host of new chilli hybrids that can be grown by crossing domesticated peppers with their wild cousins. This will allow plant breeders to create new varieties that have better disease resistance and could increase productivity.

Despite their huge world-wide culinary appeal, chillies are relatively difficult to cultivate, being prone to disease and sensitive to growing conditions.

There are 35 species of pepper in the Capsicum family, including five domesticated species. The most well-known of these is C. annum, which includes several varieties with widely differing shapes and tastes, including bell peppers, jalapeños, New Mexico chiles, and cayenne peppers.

The team of scientists from the World Vegetable Centre in Taiwan investigated the genetic relatedness between 38 samples of 15 species of wild and domesticated peppers collected from locations around the world.

Their findings, published in the journal, PLOS ONE, found that breeding compatibility between species was not necessarily connected to how closely related they were to each other.

They also discovered that four species were wrongly characterised.

Lead author of the study, Catherine Parry, collected the data whilst on a six-month work placement at the World Vegetable Centre as part of her undergraduate degree in Biology at the University of Bath.

She said: "The main differences between peppers that are grown for culinary purposes and their wild counterparts are that the wild species have much smaller fruits and leaves.

"However, we have large gaps in our understanding of the wild relatives of the Capsicum family.

"It was previously thought that only a narrow range of species could be successfully hybridised for cultivation, but our research has shown that there is a much wider potential number of varieties that could be grown.

"Many of the wild species have better disease resistance and so our findings could be valuable for identifying candidates for future breeding programmes, potentially increasing productivity for food producers and maybe even creating some new flavours to explore too!"

The World Vegetable Centre, Taiwan, holds the largest collection of Capsicum genetic material globally.

Dr Derek Barchenger, from the World Vegetable Centre and second author on the study, said: "Unlike other crops in Solanaceae, the use of wild relatives in pepper/chilli/chile pepper breeding programs is extremely limited.

"In fact the phylogeny of Capsicum is still not completely resolved.

"There are many important abiotic and biotic stresses to which we lack sources of resistance and tolerance.

"Therefore, we are interested in exploring the wild relatives of Capsicum to identity resistant sources to incorporate into our breeding program.

"This study provides a critical first step in the utilisation of Capsicum wild relatives in breeding by expanding our understanding of genetic and phenotypic similarities and cross-ability among wild and domesticated species."

There are 35 species of pepper in the Capsicum family, including five domesticated species. **CREDIT:** World Vegetable Centre

CACTUS PEAR AS DROUGHT-TOLERANT CROP FOR SUSTAINABLE FUEL AND FOOD

Could cactus pear become a major crop like soybeans and corn in the near future, and help provide a biofuel source, as well as a sustainable food and forage crop? According to a recently published study, researchers from the University of Nevada, Reno believe the plant, with its high heat tolerance and low water use, may be able to provide fuel and food in places that previously haven't been able to grow much in the way of sustainable crops.

Global climate change models predict that long-term drought events will increase in duration and intensity, resulting in both higher temperatures and lower levels of available water. Many crops, such as rice, corn and soybeans, have an upper temperature limit, and other traditional crops, such as alfalfa, require more water than what might be available in the future.

"Dry areas are going to get dryer because of climate change," Biochemistry & Molecular Biology Professor John Cushman, with the University's College of Agriculture, Biotechnology & Natural Resources, said. "Ultimately, we're going to see more and more of these drought issues affecting crops such as corn and soybeans in the future."

Fueling renewable energy

As part of the College's Experiment Station unit, Cushman and his team recently published the results of a five-year study on the use of spineless cactus pear as a high-temperature, low-water commercial crop. The study, funded by the Experiment Station and the U.S. Department of Agriculture's National Institute of Food and Agriculture, was the first long-term field trial of Opuntia species in the U.S. as a scalable bioenergy feedstock to replace fossil fuel.

Results of the study, which took place at the Experiment Station's Southern Nevada Field Lab in Logandale, Nevada, showed that Opuntia ficus-indica had the highest fruit production while using up to 80% less water than some traditional crops. Co-authors included Carol Bishop, with the College's Extension unit, postdoctoral research scholar Dhurba Neupane, and graduate students Nicholas Alexander Niechayev and Jesse Mayer.

"Maize and sugar cane are the major bioenergy crops right now, but use three to six times more water than cactus pear," Cushman said. "This study showed that cactus pear productivity is on par with these important bioenergy crops, but use a fraction of the water and have a higher heat tolerance, which makes them a much more climate-resilient crop."

Cactus pear works well as a bioenergy crop because it is a versatile perennial crop. When it's not being harvested for biofuel, then it works as a land-based carbon sink, removing carbon dioxide from the atmosphere and storing it in a sustainable manner.

"Approximately 42% of land area around the world is classified as semi-arid or arid," Cushman said. "There is enormous potential for planting cactus trees for carbon sequestration. We can start growing cactus pear crops in abandoned areas that are marginal and may not be suitable for other crops, thereby expanding the area being used for bioenergy production."

Fueling people and animals

The crop can also be used for human consumption and livestock feed. Cactus pear is already used in many semi-arid areas around the world for food and forage due to its low-water needs compared with more traditional crops. The fruit can be used for jams and jellies due to its high sugar content, and the pads are eaten both fresh and as a canned vegetable. Because the plant's pads are made of 90% water, the crop works great for livestock feed as well.

"That's the benefit of this perennial crop," Cushman explained. "You've harvested the fruit and the pads for food, then you have this large amount of biomass sitting on the land that is sequestering carbon and can be used for biofuel production."

Cushman also hopes to use cactus pear genes to improve the water-use efficiency of other crops. One of the ways cactus pear retains water is by closing its pores during the heat of day to prevent evaporation and opening them at night to breathe. Cushman wants to take the cactus pear genes that allow it to do this, and add them to the genetic makeup of other plants to increase their drought tolerance.

Bishop, Extension educator for Northeast Clark County, and her team, which includes Moapa Valley High School students, continue to help maintain and harvest the more than 250 cactus pear plants still grown at the field lab in Logandale. In addition, during the study, the students gained valuable experience helping to spread awareness about the project, its goals, and the plant's potential benefits and uses. They produced videos, papers, brochures and recipes; gave tours of the field lab; and held classes, including harvesting and cooking classes.

Fueling further research

In 2019, Cushman began a new research project with cactus pear at the U.S. Department of Agriculture -- Agricultural Research Service' National Arid Land Plant Genetic Resources Unit in Parlier, California. In addition to continuing to take measurements of how much the cactus crop will produce, Cushman's team, in collaboration with Claire Heinitz, curator at the unit, is looking at which accessions, or unique samples of plant tissue or seeds with different genetic traits, provide the greatest production and optimise the crop's growing conditions.

"We want a spineless cactus pear that will grow fast and produce a lot of biomass," Cushman said.

One of the other goals of the project is to learn more about Opuntia stunting disease, which causes cactuses to grow smaller pads and fruit. The team is taking samples from the infected plants to look at the DNA and RNA to find what causes the disease and how it is transferred to other cactuses in the field. The hope is to use the information to create a diagnostic tool and treatment to detect and prevent the disease's spread and to salvage usable parts from diseased plants.

Journal Reference:

Dhurba Neupane, Jesse A. Mayer, Nicholas A. Niechayev, Carol D. Bishop, John C. Cushman. Five-year field trial of the biomass productivity and water input response of cactus pear (Opuntia spp.) as a bioenergy feedstock for arid lands. GCB Bioenergy, 2021; DOI: 10.1111/gcbb.12805

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PHOTOSYNTHESIS: OUR BEST BET TO CREATE A FOOD SECURE WORLD

Australian agriculture plays a key role towards providing food for the planet but it is also expected to be one of the world's most impacted areas from climate change.

Currently, Australia exports and produces more food than it consumes, but this could change drastically, if we don't build crop resilience to deal with the consequences of climate extremes.

The good news is that Australia also has an unusual concentration of experts in what is considered to be one of the best solutions to increase and sustain cereal crop production: improving photosynthesis.

"Improving photosynthesis is our best option to achieve global food security and we know how to do it. Australia has always punched above its weight in photosynthesis research, with major discoveries coming out of this country," says Professor Robert Furbank, Director of the ARC Centre of Excellence for Translational Photosynthesis.

The ARC Centre of Excellence for Translational Photosynthesis is a collaborative initiative established in 2014 with the ambitious aim of improving the process by which plants transform sunlight and carbon dioxide into sugars, a process that underlines all food production.

This week the Centre launched a video about the impact of its work on food security, produced in collaboration with the Australian Academy of Science as part of their Series Research Focus.

"We are at a point where we have the potential to have large scale impact towards increasing Australian cereal crop production. We have the proof of concept for many of the innovations we have developed during these years of work. Now we have crop plants that have improvements in photosynthesis, but we really need research funding to continue, as breeding a new variety can take up to 10 years," says Professor Furbank.

Since 2014, the Centre has identified several crop germplasm lines carrying improved traits in wheat, rice and sorghum and transplanted beneficial photosynthetic traits into crop species. This work has been published in more than 300 scientific publications.

"Now it is a matter for the government and industry to apply these exciting discoveries into mainstream crop varieties and improve agricultural profitability, crop resilience, sustainability and food security," Professor Furbank says.

The Australian Research Council (ARC) Centre of Excellence for Translational Photosynthesis (CoETP), led by the Australian National University, aims to improve the process of photosynthesis to increase the production of major food crops such as sorghum, wheat and rice.

Journal Reference:

Professor Graeme Hammer, Centre for Crop Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland, Dr Alex Wu, Researcher, CoETP, Centre for Crop Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland

PLANT CLOCK COULD BE THE KEY TO PRODUCING MORE FOOD FOR THE WORLD

A University of Melbourne led study has established how plants use their metabolism to tell time and know when to grow -- a discovery that could help leverage growing crops in different environments, including different seasons, different latitudes or even in artificial environments and vertical gardens.

Published in the PNAS journal, Superoxide is promoted by sucrose and affects amplitude of circadian rhythms in the evening, details how plants use their metabolism to sense time at dusk and help conserve energy produced from sunlight during the day.

Lead researcher Dr Mike Haydon, from the School of BioSciences, said while plants don't sleep as humans do, their metabolism is adjusted during the night to conserve energy for the big day ahead of making their own food using energy from sunlight, or photosynthesis.

"Getting the timing of this daily cycle of metabolism right is really important because getting it wrong is detrimental to growth and survival," Dr Haydon said. "Plants can't stumble to the fridge in the middle of the night if they get hungry so they have to predict the length of the night so there's enough energy to last until sunrise; a bit like setting an alarm clock."

Dr Haydon and collaborators had earlier shown that the accumulation of sugars produced from photosynthesis give the plant important information about the amount of sugar generated in the morning and sends signals to what's known as the circadian clock, to adjust its pace.

"We have now found that a different metabolic signal, called superoxide, acts at dusk and changes the activity of circadian clock genes in the evening," said Dr Haydon. "We also found that this signal affects plant growth. We think this signal could be providing information to the plant about metabolic activity as the sun sets."

Researchers hope the study will be invaluable in the world producing more food, more reliably.

"As we strive to produce more food for the increasing global population in the face of changing climate, we may need to grow crops in different environments such as different seasons, different latitudes or even in artificial environments like vertical gardens," Dr Haydon said.

"Understanding how plants optimise rhythms of metabolism could be useful information to allow us to fine-tune their circadian clocks to suit these conditions and maximise future yields."

Journal Reference:

Haydon, Michael; Davey, John; Román, Ángela. Superoxide is promoted by sucrose and affects amplitude of circadian rhythms in the evening. PNAS, 2021 DOI: 10.1073/pnas.2020646118

CRITICALLY ENDANGERED MACADAMIA SPECIES BECOMES A PLANT SUPERMODEL

One of the world's rarest tree species has been transformed into a sophisticated model that University of Queensland researchers say is the future of plant research.

"Macadamia jansenii is a critically endangered species of macadamia which was only described as a new species in 1991," said Robert Henry, Professor of Innovation at the Queensland Alliance for Agriculture and Food Innovation (QAAFI).

Macadamia jansenii raceme

"It grows near Miriam Vale in Queensland and there are only around 100 known trees in existence."

Nuts from M. integrifolia and M. jansenii. Photo courtesy of Scott Lamond

However, with funding from Hort Innovation's Tree Genomics project, and UQ's Genome Innovation Hub Macadamia jansenii has now become the world's most sophisticated plant research model.

Professor Henry said Macadamia jansenii was probably the best studied species on the planet in terms of its genetics.

"Macadamia jansenii has potentially become the model for assembling all future plant genomes," he said.

Professor Henry said the entire jansenii species grows in one small area.

"This means we have the potential to study the diversity of the whole species," he said.

"This is unusual, even for rare or endangered plants – it means we can get a lot of information about how rare plant species survive the impact of small population size and the associated genetic bottleneck.

Professor Henry said that particular characteristics of Macadamia jansenii made it useful for improving the technology and methodology for sequencing and assembling plant genomes.

"We investigated the different sequencing technologies, all the different software and algorithms that you can use in genomic sequencing, and then applied each of them to the same sample to find out what worked best," he said.

"It's a long, complex and very expensive process, so we wanted to use the latest technology to improve its efficiency."

The Genome Innovation Hub's Ms Valentine Murigneux analysed the genome sequence and QAAFI researchers then assembled all 14 chromosomes for the species, in collaboration with laboratories in the United States. This work was published in GigaScience.

Ray Jansen portrait painting - artist unknown. Photo by Ian McConachie. Image supplied by Macadamia Conservation Trust.

Professor Henry said the work is of great interest globally.

"High quality genome sequences are proving much more useful than rough draft sequences with less errors and better outcomes for plant breeding," he said.

Macadamia jansenii was first brought to the attention of Western plant scientists in 1983, by Ray Jansen, a canefarmer and skilled amateur botanist from a South Kolan in Central Queensland.

Denise Bond, Executive Officer, Macadamia Conservation Trust

Ms Denise Bond, Executive Officer of the Macadamia Conservation Trust said since 2018 about 60 new mature Macadamia jansenii trees have been located, although a quarter of these were destroyed in the bush fires of 2019.

"We very much welcome the genomic research on Macadamia jansenii as it will help prioritise future conservation efforts, although right now the most critical thing is to protect the remaining wild trees in their original habitat," Ms Bond said.

She said the remaining three macadamias species – M. ternifolia, M. tetraphylla and M. integrifola – were listed on the International Union for Conservation of Nature's Red List of Threatened Species in 2020.

"This is a wake-up call to Australia to take better care of our native macadamia species."

Professor Henry said all four macadamia species – tetraphylla, integrifolia, ternifolia and jansenii have now undergone the same analysis.

"It is fitting this work has been developed in Queensland using the Macadamia genus – one of Australia's few additions to the world's food crops," he said

The macadamia genomic work forms part of a five-year project to develop detailed high quality genome sequencing for five of Australia's key horticultural tree crops – avocado, macadamia, mango, citrus and almond – which account for 80 percent of Australian horticulture tree crop value.

"The macadamia data we have generated has been fed through to a range of projects including research on sustainably intensifying tree crop production and breeding for key commercial attributes in macadamia production," Professor Henry said.

This project is funded by Hort Innovation, the Department of Agriculture and Fisheries Queensland and The University of Queensland.

Journal Reference:

Valentine Murigneux, Subash Kumar Rai, Agnelo Furtado, Timothy J C Bruxner, Wei Tian, Ivon Harliwong, Hanmin Wei, Bicheng Yang, Qianyu Ye, Ellis Anderson, Qing Mao, Radoje Drmanac, Ou Wang, Brock A Peters, Mengyang Xu, Pei Wu, Bruce Topp, Lachlan J M Coin, Robert J Henry, Comparison of long-read methods for sequencing and assembly of a plant genome,GigaScience, Volume 9, Issue 12, December 2020, giaa146, https://doi.org/10.1093/gigascience/giaa146

FARM-LEVEL STUDY SHOWS RISING TEMPERATURES HURT RICE YIELDS

A study of the relationship between temperature and yields of various rice varieties, based on 50 years of weather and rice-yield data from farms in the Philippines, suggests that warming temperatures negatively affect rice yields.

Recent varieties of rice, bred for environmental stresses like heat, showed better yields than both traditional rice varieties and modern varieties of rice that were not specifically bred to withstand warmer temperatures. But the study found that warming adversely affected crop yields even for those varieties best suited to the heat. Overall, the advantage of varieties bred to withstand increased heat was too small to be statistically significant.

One of the top 10 countries globally in rice production, the Philippines is also a top-10 rice importer, as domestic supply cannot meet demand.

Roderick Rejesus, a professor and extension specialist of agricultural and resource economics at North Carolina State University and the corresponding author of a paper that describes the study, says that teasing out the effects of temperature on rice yields is important to understand whether rice-breeding efforts have helped address the environmental challenges faced by modern society, such as global warming.

The study examined rice yields and atmospheric conditions from 1966 to 2016 in Central Luzon, the major rice-growing region of the Philippines. Rejesus and study colleagues were able to utilise farm-level data of rice yields and area weather conditions in four-to-five-year increments over the 50-year period, a rare data trove that allowed the researchers to painstakingly examine the relationship between rice yield and temperature in actual farm environments.

"This rich data set allowed us to see what was actually happening at the farm level, rather than only observing behaviour at higher levels of aggregation like in provinces or districts," Rejesus said.

The study examined three general rice varieties planted during those 50 years: traditional rice varieties; "early modern varieties" planted after the onset of the Green Revolution, which were bred for higher yields; and "recent modern varieties" bred for particular characteristics, like heat or pest resistance, for example.

Perhaps as expected, the study showed that, in the presence of warming, recent modern varieties had the best yields when compared with the early modern and traditional varieties, and that early modern varieties outperformed traditional varieties. Interestingly, some of the early modern varieties may have also mitigated heat challenges given their smaller "semi-dwarf" plant architecture, even though they were not bred to specifically resist heat.

"Taken all together, there are two main implications here," Rejesus said. "The first is that, at the farm level, there appears to be a 'yield gap' between how rice performs in breeding trials and on farms, with farm performance of recent varieties bred to be more tolerant to environmental stresses not being statistically different relative to the older varieties.

"The second is that rice breeding efforts may not have reached their full potential such that it may be possible to produce new varieties that will statistically perform better than older varieties in a farm setting."

Rejesus also acknowledged that the study's modest sample size may have contributed to the inability to find statistical significance in the differences in warming impacts between rice varietal yields.

"This paper has implications for other rice-breeding countries, like Vietnam, because the timing of the release of various rice varieties is somewhat similar to that of the Philippines," Rejesus said. "Plant-breeding institutions can learn from this type of analysis, too. It provides guidance as to where research funding may be allocated by policymakers to further improve the high temperature tolerance of rice varieties available to farmers."

Rejesus plans to further study other agricultural practices and innovations that affect crop yields, including an examination of cover crops, or plants grown on cropland in the off season that aim to keep soils healthy, to gauge whether they can mitigate the adverse impacts of a changing climate.

Journal Reference:

Ruixue Wang, Roderick M. Rejesus, Jesse B. Tack, Joseph V. Balagtas, Andy D. Nelson. Quantifying the Yield Sensitivity of Modern Rice Varieties to Warming Temperatures: Evidence from the Philippines. American Journal of Agricultural Economics, 2021; DOI: 10.1111/ajae.12210

FEEDING CATTLE SEAWEED REDUCES THEIR GREENHOUSE GAS EMISSIONS 82 PERCENT

A bit of seaweed in cattle feed could reduce methane emissions from beef cattle as much as 82 percent, according to new findings from researchers at the University of California, Davis. The results, published today (March 17) in the journal PLOS ONE, could pave the way for the sustainable production of livestock throughout the world.

"We now have sound evidence that seaweed in cattle diet is effective at reducing greenhouse gases and that the efficacy does not diminish over time," said Ermias Kebreab, professor and Sesnon Endowed Chair of the Department of Animal Science and director of the World Food Center. Kebreab conducted the study along with his Ph.D. graduate student Breanna Roque.

"This could help farmers sustainably produce the beef and dairy products we need to feed the world," Roque added.

Over the course of five months last summer, Kebreab and Roque added scant amounts of seaweed to the diet of 21 beef cattle and tracked their weight gain and methane emissions. Cattle that consumed doses of about 80 grams (3 ounces) of seaweed gained as much weight as their herd mates while burping out 82 percent less methane into the atmosphere. Kebreab and Roque are building on their earlier work with dairy cattle, which was the world's first experiment reported that used seaweed in cattle.

Less gassy, more sustainable

Greenhouse gases are a major cause of climate change, and methane is a potent greenhouse gas. Agriculture is responsible for 10 percent of greenhouse gas emissions in the U.S., and half of those come from cows and other ruminant animals that belch methane and other gases throughout the day as they digest forages like grass and hay.

Since cattle are the top agricultural source of greenhouse gases, many have suggested people eat less meat to help address climate change. Kebreab looks to cattle nutrition instead.

"Only a tiny fraction of the earth is fit for crop production," Kebreab explained. "Much more land is suitable only for grazing, so livestock plays a vital role in feeding the 10 billion people who will soon inhabit the planet. Since much of livestock's methane emissions come from the animal itself, nutrition plays a big role in finding solutions."

In 2018, Kebreab and Roque were able to reduce methane emissions from dairy cows by over 50 percent by supplementing their diet with seaweed for two weeks. The seaweed inhibits an enzyme in the cow's digestive system that contributes to methane production.

In the new study, Kebreab and Roque tested whether those reductions were sustainable over time by feeding cows a touch of seaweed every day for five months, from the time they were young on the range through their later days on the feed lot.

Four times a day, the cows ate a snack from an open-air contraption that measured the methane in their breath. The results were clear. Cattle that consumed seaweed emitted much less methane, and there was no drop-off in efficacy over time.

Next steps

Results from a taste-test panel found no differences in the flavor of the beef from seaweed-fed steers compared with a control group. Similar tests with dairy cattle showed that seaweed had no impact on the taste of milk.

Also, scientists are studying ways to farm the type of seaweed -- Asparagopsis taxiformis -- that Kebreab's team used in the tests. There is not enough of it in the wild for broad application.

Another challenge: How do ranchers provide seaweed supplements to grazing cattle on the open range? That's the subject of Kebreab's next study.

Kebreab and Roque collaborated with a federal scientific agency in Australia called the Commonwealth Scientific and Industrial Research Organization, James Cook University in Australia, Meat and Livestock Australia, and Blue Ocean Barns, a startup company that sources, processes, markets and certifies seaweed-based additives to cattle feed. Kebreab is a scientific adviser to Blue Ocean Barns.

"There is more work to be done, but we are very encouraged by these results," Roque said. "We now have a clear answer to the question of whether seaweed supplements can sustainably reduce livestock methane emissions and its long term effectiveness."

Support for the research comes from Blue Ocean Barns, the David and Lucile Packard Foundation and the Grantham Foundation.

EXPLORING THE CULTURAL HERITAGE AND NUTRITION OF WATTLE SEEDS

Author: Ms Sera Jacob
PhD Candidate
Centre for Nutrition and Food Sciences

Sera Susan Jacob is currently working with Australian native wattle seeds. Wattle seeds are a nutrient powerhouse full of iron, fibre, and protein and offer an exciting and unique potential as a major food ingredient in conventional food options. She is looking at different varieties harvested around Alice Springs along with different processing methods to better improve the way our bodies absorb nutrients from these seeds. Sera's work also focuses on Indigenous engagement and ethically understanding the traditional knowledge connected to wattle seeds. This project is under the ARC Training Centre for Uniquely Australian Food and supported by Karen Sheldon Catering. Her advisors are Prof Mike Gidley, A/Prof Heather Smyth, Dr Bernadine Flanagan, and Dr Barbara Williams.

A journey to Australia's red centre changed me forever. I visited Alice Springs for my first industry placement as part of my PhD research on Australian native wattle seeds.

Alice Springs offers an unspoken embrace as soon as you step off the aeroplane. Post COVID-19 formalities, I was out of the airport, more prepared than ever for the days ahead and ready to share and learn about the beautiful history and tales surrounding the wattle seeds.

Wattle seeds (Acacia sp.) have historically been an integral part of the Australian Aboriginal diet. Full of protein, useful dietary fibre, iron and zinc, the seeds from specific varieties hold a lot of significance both nutritionally and spiritually in their lives. As both a scientist and someone who holds my tradition and culture close to my heart, I was thrilled at the opportunity to interact with and learn about them.

I was able to assist with the Future stars Training Program, which is a monthly training program organized by Saltbush Enterprises of Karen Sheldon Group (KSG). The training program is an Indigenous pre-employment program aimed at empowering local Aboriginal jobseekers by training them with life skills and improving their employability as a significant contribution towards closing the gap on Indigenous economic disadvantage. Sarah Hickey, partner, and Business Development Manager at KSC and Director of Saltbush Enterprises was a delight to meet, her energy truly infectious. We worked together for the initial and busiest four days of the visit.

Caption: Future Stars trainer John, Sera Jacob, Rayleen Brown, Coordinator Vivienne. © Sera Susan Jacob, UQ

Over the span of two weeks, I also had the privilege to spend time daily with Rayleen Brown, owner of Kungkas Can Cook, trainer for the Future Stars Program with KSG and a widely renowned advocate for indigenous cultural protection and empowerment. The passion and dedication she displays for her work was evident in every conversation we had. We had many lengthy discussions where we bonded over personal stories and shared a common excitement for interesting topics to explore during my research. I even assisted her as she undertook yet another one of her amazing masterclasses on the culinary wonders of the desert, beautifully set up on the Larapinta Trail.

Treats made using different varieties of roasted wattle seeds. (Meringues with wattle seed cream, glazed quandongs and bush passionfruit syrup) © Sera Susan Jacob, UQ

In due course, I made friends with many of the participants and other coordinators of the program. Their smiles and our conversations about everything and anything are fond memories I will always cherish. We were able to work together on many occasions, the most notable being at the famous Parrtjima light festival – a cultural celebration of light shows, food and upcoming and established Indigenous artists. A masterclass on incorporating bushfoods into conventional cooking assisted by the wonderful participants of the Future Stars program and led by Rayleen Brown and Mark Oliver (fondly known as Black Olive). I was in awe by the beautiful colours, flavours and textures I got to experience.

Overall. Alice Springs was far beyond anything I ever imagined a field trip would be. I returned home to Brisbane after two weeks, my mind brimming with ideas and stories and my heart full of love.

Wattleseed damper © Sera Susan Jacob, UQ

Native seeds, particularly wattle seeds (pictured) will be explored in terms of bioavailability of dietary fibre, starch and phytonutrients in partnership with Karen Sheldon Catering. The project will involve exploring different cultivars of wattle seeds for nutritional properties in gut models to identify product-specific market opportunities.

NOT JUST CO2: RISING TEMPERATURES ALSO ALTER PHOTOSYNTHESIS IN A CHANGING CLIMATE

Agricultural scientists who study climate change often focus on how increasing atmospheric carbon dioxide levels will affect crop yields. But rising temperatures are likely to complicate the picture, researchers report in a new review of the topic.

Published in the Journal of Experimental Botany, the review explores how higher temperatures influence plant growth and viability despite the greater availability of atmospheric CO2, a key component of photosynthesis.

Excessive heat can reduce the efficiency of enzymes that drive photosynthesis and can hinder plants' ability to regulate CO2 uptake and water loss, the researchers write. Structural features can make plants more -- or less -- susceptible to heat stress. Ecosystem attributes -- such as the size and density of plants, the arrangement of leaves on plants or local atmospheric conditions -- also influence how heat will affect crop yields.

The review describes the latest scientific efforts to address these challenges.

"It's important to have an understanding of these issues across scales -- from the biochemistry of individual leaves to ecosystem-level influences -- in order to really tackle these problems in an informed way," said lead author Caitlin Moore, a research fellow at the University of Western Australia and an affiliate research fellow at the Institute for Sustainability, Energy, and Environment at the University of Illinois Urbana-Champaign. Moore led the review with Amanda Cavanagh, another U. of I. alumna now at the University of Essex in the U.K.

"Historically, there's been a lot of focus on rising CO2 and the impact that it has on plants," said co-author Carl Bernacchi, a professor of plant biology and of crop sciences and an affiliate of the Carl R. Woese Institute for Genomic Biology at the U. of I. "And it is an important factor, because we are changing that carbon dioxide concentration enormously. But it's a small part of the bigger story. Once you throw changing temperatures into the mix, it completely messes up our understanding of how plants are going to respond."

"Take Rubisco, the key enzyme that fixes carbon dioxide into sugars, making life on Earth possible," Cavanagh said. "Rubisco speeds up as the temperature increases, but it's also prone to making mistakes."

Instead of fixing carbon dioxide by binding it to sugars, a key step in photosynthesis, Rubisco sometimes fixes oxygen, initiating a different pathway that wastes a plant's resources. Higher temperatures make this more likely, Cavanagh said. At even higher temperatures, the enzyme will begin to lose its structural integrity, making it ineffective.

Excessive heat can also undermine a plant's reproductive output. Other heat-sensitive enzymes are essential to the light-harvesting machinery of plants or play a role in moving sugars to different plant tissues, allowing the plant to grow and produce grains or fruits.

"If these little molecular machines are pushed out of the temperature range that's optimal, then they can't do their job," Cavanagh said.

When temperatures rise too high, plant leaves open the pores on their surfaces, called stomata, to cool themselves. Stomata also allow plants to absorb carbon dioxide from the atmosphere, but when they're fully open, the leaf can lose too much moisture.

"Temperature affects the atmosphere above the plant," Moore said. "As the atmosphere heats up, it can hold additional water, so it's pulling more water from the plants."

Scientists at Illinois and elsewhere are looking for ways to enhance crop plants' resilience in the face of these changes. Moore, whose work focuses on ecosystem-scale factors, said new tools that can help screen plants on a large scale are essential to that effort. For example, satellites that can detect changes in chlorophyll fluorescence in plants can indicate whether a crop is under heat stress. These changes in fluorescence are detectable before the plant shows any outward sign of heat stress -- such as their leaves turning brown. Developing these tools may enable farmers to respond more quickly to crop stress before too much damage is done.

Cavanagh, who studies the molecular biology and physiology of plants, said some plants are more heat tolerant than others, and scientists are searching their genomes for clues to their success.

"For example, you can look at wild Australian relatives of rice that are growing in much harsher climates than most paddy rices," she said. "And you see that their enzymes are primed to work more efficiently at hotter temperatures."

One goal is to transfer heat-tolerant genes to cultivated rice varieties that are more susceptible to heat stress.

Other strategies include engineering structures that pump more CO2 to the site of carbon fixation to improve Rubisco efficiency; altering the light-gathering properties of leaves at the tops and bottoms of plants to even out distribution of sunlight and maintain moisture levels; and changing the density of stomata to improve their control of CO2 influx and moisture loss.

Collaboration between scientists focused on different scales of ecosystem and plant function -- from the atmospheric to the molecular -- is essential to the success of efforts to build resilience in crop plants, the researchers said.

"The world is getting hotter at a shocking rate," Cavanagh said. "And we know from global models that each increase in gross temperature degree Celsius can cause 3% to 7% losses in yield of our four main crops. So, it's not something we can ignore.

"What makes me optimistic is the realisation that so much work is going into globally solving this problem," she said.

Journal Reference:

Caitlin E Moore, Katherine Meacham-Hensold, Pauline Lemonnier, Rebecca A Slattery, Claire Benjamin, Carl J Bernacchi, Tracy Lawson, Amanda P Cavanagh. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Journal of Experimental Botany, 2021; DOI: 10.1093/jxb/erab090

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HOTTER, DRIER, CRISPR: EDITING FOR CLIMATE CHANGE

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

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.

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

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

In proof-of-concept studies, Dr Massel 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 digestibility 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."

Dr Karen Massel in the UQ laboratory lab.

Dr Massel'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.

Journal Reference:

This research is published in Theoretical and Applied Genetics (January 2021) DOI: 10.1007/s00122-020-03764-0.
Massel, K., Lam, Y., Wong, A.C.S., Hickey, L.T., Borrell, A.K. and Godwin, I.D. Hotter, drier, CRISPR: the latest edit on climate change. Theor Appl Genet (8 January 2021). doi: 10.1007/s00122-020-03764-0.

PROTEIN DISCOVERY COULD HELP ENABLE ECO-FRIENDLY FUNGICIDES

New research reveals an essential step in scientists' quest to create targeted, more eco-friendly fungicides that protect food crops.

Scientists have known for decades that biological cells manufacture tiny, round structures called extracellular vesicles. However, their pivotal roles in communication between invading microorganisms and their hosts were recognised only recently.

UC Riverside geneticist Hailing Jin and her team found plants use these vesicles to launch RNA molecules at fungal invaders, suppressing the genes that make the fungi dangerous.

"These vesicles shuttle small RNAs between cells, like tiny Trojan horses with weapons hidden inside," said Jin, a professor of genetics and the Cy Mouradick Chair in the Department of Plant Pathology and Microbiology. "They can silence pathogenic fungal gene expression."

Using extracellular vesicles and small RNAs has several advantages over conventional fungicides. They're more eco-friendly because they are similar to naturally occurring products. Eventually, they degrade and do not leave toxic residues in the soil. Also, Jin explained, this method of fighting fungi is less likely to breed drug-resistant pathogens.

A sticking point for scientists in creating these fungicides has been figuring out how to load their desired small RNAs into the vesicles.

"We've wondered how these weaponised small RNAs get into the bubbles," Jin said. "Now, we think we have an answer."

Her laboratory has identified several proteins that serve as binding agents, helping to select and load small RNAs into the vesicles. The lab's research is detailed in a new Nature Plants journal article.

The Jin laboratory has been working for several years on the development of gene-silencing RNA fungicides. Work toward this goal led to the team's landmark discovery in 2013 that gene-silencing RNA messages can be sent from the fungal pathogen to the plant host to suppress host immunity. Later, the team learned small RNAs can move both ways -- from plants into pathogenic invader cells as well.

In 2018, the team worked out that extracellular vesicles were the major delivery system for these small RNAs. They observed that Arabidopsis plants secrete extracellular vesicles into Botrytis cinerea, a fungus that causes grey mold disease and destroys millions of crops every year.

"This was the first example of a host using these vesicles to deliver small RNAs to another organism," Jin said. "Previously we saw movement of RNA, but didn't know how the small RNA are selected and transported."

Now, she and her colleagues have identified several RNA-binding proteins in Arabidopsis that bind to specific small RNA molecules and load them into extracellular vesicles. This suggests the proteins play an important role in loading and stabilising small RNAs in the vesicles. The finding can help increase the payload of gene-silencing RNAs that make it into vesicles and enhance the efficiency of disease control.

Some scientists have taken inspiration from the RNA communication in plant vesicles to design human therapies. For example, some are attempting to load anti-cancer RNAs and drugs into extracellular vesicles in fruits or vegetables, so people can eat or drink them. Jin is hopeful that her lab's discovery can aid these efforts.

Journal Reference:

Baoye He, Qiang Cai, Lulu Qiao, Chien-Yu Huang, Shumei Wang, Weili Miao, Tommy Ha, Yinsheng Wang, Hailing Jin. RNA-binding proteins contribute to small RNA loading in plant extracellular vesicles. Nature Plants, 2021; DOI: 10.1038/s41477-021-00863-8

MUNGBEANS UNMASKED

New research in Queensland aims to improve mungbean yields in an increasingly variable climate. It will also provide essential information about the key factors influencing plant growth and yields.

Mungbean (Vigna radiata) is a high-value summer legume crop, returning an average of $1100 per tonne to growers. As a legume, it has the ability to fix nitrogen and improve soil productivity, which makes it an attractive option for growers in Queensland and northern NSW.

It is a valuable export crop for Australia. The average annual production over the past five years has been 90,000 tonnes, according to the Australian Mungbean Association (AMA), and 90 per cent of the crop is exported.

Geetika Geetika in the field with a Ceptometer to measure solar radiation incident on the mungbean crop.

At the University of Queensland, Geetika Geetika is focused on identifying the traits that limit mungbean yields. As part of her PhD research for the Queensland Alliance of Agriculture and Food Innovation (QAAFI) Geetika aims to improve the overall understanding of crop physiology, improve the consistency of crop production and, ultimately, help lift Australia's average yield from one to 1.5 tonnes/hectare.

Yields can range from bumper crops of up to three tonnes down to as little as 0.2 tonnes, depending on seasonal influences, such as the timing of extreme temperatures or lack of rain. Good yields to date have largely been reliant on good seasonal conditions.

Her research is part of a five-year GRDC collaboration, 'Optimising Mungbean Yields', which runs until 2023, with Associate Professor Rao (RCN) Rachaputi as her supervisor.

The PhD project spans the crop's canopy development and phenology; vegetative biomass accumulation, canopy light capture and reproductive growth; and genotype differences in plant physiology. This broad scope reflects the shortfall in the current biological understanding of the plant's lifecycle.

Geetika's findings are expected to help direct plant breeding efforts and identify management strategies that growers can use to improve yields.

Mungbean development

In experiments in the 2018–2019 summer, she examined the crop phenology and pod development of five mungbean cultivars and a variety from a related crop species known as black gram or mungo bean (Vigna mungo).

The mungbean cultivars were Berken, Celera II-AU, Jade-AU, Satin II, and Opal-AU. The black gram variety was Onyx-AU.

Preliminary findings from the trial have brought the crop's critical developmental phases into sharp focus, helping identify the plant's source-sink relationship – the movement of photosynthetic products from regions of supply (source), such as leaves, to regions of use or storage (sink), such as grain.

"Flowering and pod development influence the plant's source-sink relationships," Geetika says. She found that mungbeans tend to rapidly flower and pod, and stop producing leaves on the plant's main stem during these reproductive growth stages.

This could be linked to the 'determinate' growth of mungbean – leaf production on the main stem stops once the plant achieves a genetically predetermined stage of development, she says.

"The last (trifoliate) leaf formed on the main stem of mungbean plants was smaller than the others, and the plant's growing tip, or apical meristem, develops into a flower bud."

Associate Professor RCN Rachaputi and Ms Geetika inspecting the mungbean seeds in a field experiment at Gatton.

Journal Reference:

Ms Geetika Geetika, PhD candidate, Centre for Crop Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland

Rachaputi, Principal Research Fellow (Grain Legumes), QAAFI at UQ Gatton

Vegetative biomass

Geetika has also investigated how the accumulation of vegetative biomass might influence mungbean yields. Vegetative biomass was assessed based on the crop canopy's ability to capture light.

Different types of crop canopies create different gradients of the light extinction coefficient and light use efficiency that shape vegetative growth. This growth determines how much light plants can receive and convert into biomass.

"Increased biomass production is linked to improved light capture in crops," Geetika says.

Mungbean is typically sown on 0.5 to 1 metre row spacing using varying plant population densities. However, mungbeans sown on narrower row spacings tend to produce more vegetative biomass and have higher yield potential due to improved light capture.

Ms Geetika and Dr Kylie Wenham
inspecting mungbean crop grown in a field experiment at the UQ Gatton research station.

Canopy density

Geetika tested the yield impacts of crop canopy density in paddock trials at the University of Queensland's Gatton campus in 2019 and 2020.

Jade-AU and Satin II mungbean varieties were sown on narrow 0.5 metre row-spacings at a rate of 22 plants per square metre to promote high canopy density. These varieties were also sown on wide 1 metre row spacings at a relatively low rate of 12 plants/m2 to promote low canopy density. A third experiment looked at the yield effects of a high plant population (33 plants/m2) on both narrow and wide row spacings.

The trials found the Jade-AU variety had a slight yield advantage over Satin II, even though its crop canopy intercepted less light. Geetika says the higher yield appears to stem from Jade-AU's higher radiation use efficiency, as opposed to its canopy light capture.

"This may assist it to more efficiently produce assimilates (photosynthetic products) for use by developing pods, resulting in higher yields," she says.

Ms Geetika using a SPAD meter to assess the leaf chlorophyll density in mungbean.

Source-sink influence

Another strand of the PhD research is investigating how the source-sink relationship in mungbean plants drives crop yields.

She has established an experiment to explore whether yield is limited by assimilate production in leaves (source limitation), using shade cloth to reduce light on mungbean crops at different growth stages.

Geetika is also developing new equations, drawing on her experiment findings, to facilitate improved crop modelling and simulation. For instance, these equations will be used to simulate mungbean growth, development and yield using the Agricultural Production Systems sIMulator (APSIM).

Geetika PhD is funded by the Grains Research and Development Corporation and The University of Queensland and the Department of Agriculture and Fisheries Queensland.

ATMOSPHERIC DRYING WILL LEAD TO LOWER CROP YIELDS, SHORTER TREES ACROSS THE GLOBE

A global observation of an ongoing atmospheric drying -- known by scientists as a rise in vapor pressure deficit -- has been observed worldwide since the early 2000s. In recent years, this concerning phenomenon has been on the rise, and is predicted to amplify even more in the coming decades as climate change intensifies.

In a new paper published in the journal Global Change Biology, research from the University of Minnesota and Western University in Ontario, Canada, outlines global atmospheric drying significantly reduces productivity of both crops and non-crop plants, even under well-watered conditions. The new findings were established on a large-scale analysis covering 50 years of research and 112 plant species.

"When there is a high vapor pressure deficit, our atmosphere pulls water from other sources: animals, plants, etc.," said senior author Walid Sadok, an assistant professor in the Department of Agronomy and Plant Genetics at the University of Minnesota. "An increase in vapor pressure deficit places greater demand on the crop to use more water. In turn, this puts more pressure on farmers to ensure this demand for water is met -- either via precipitation or irrigation -- so that yields do not decrease."

"We believe a climate change-driven increase in atmospheric drying will reduce plant productivity and crop yields -- both in Minnesota and globally," said Sadok.

In their analysis, researchers suspected plants would sense and respond to this phenomenon in unexpected ways, generating additional costs on productivity. Findings bear out that various plant species -- from wheat, corn, and even birch trees -- take cues from atmospheric drying and anticipate future drought events.

Through this process, plants reprogram themselves to become more conservative -- or in other words: grow smaller, shorter and more resistant to drought, even if the drought itself does not happen. Additionally, due to this conservative behavior, plants are less able to fix atmospheric CO2 to perform photosynthesis and produce seeds. The net result? Productivity decreases.

"As we race to increase production to feed a bigger population, this is a new hurdle that will need to be cleared," said Sadok. "Atmospheric drying could limit yields, even in regions where irrigation or soil moisture is not limiting, such as Minnesota."

On a positive note, the analysis indicates different species or varieties within species respond more or less strongly to this drying depending on their evolutionary and genetic make-up. For example, in wheat, some varieties are less responsive to this new stress compared to others, and this type of variability seems to exist within other non-crop species as well.

"This finding is particularly promising as it points to the possibility of breeding for genotypes with an ability to stay productive despite the increase in atmospheric drying," said Sadok.

Danielle Way, a plant physiologist and co-author of the study from Western University, sees similar outcomes when it comes to ecosystems.

"Variation in plants' sensitivity to atmospheric drying could also be leveraged to predict how natural ecosystems will respond to climate change and manage them in ways that increase their resilience to climate change," she said.

In the future, researchers believe these findings can be used to design new crop varieties and manage ecosystems in ways that make them more resilient to atmospheric drying. However, new collaborations are needed between plant physiologists, ecologists, agronomists, breeders and farmers to make sure the right kind of variety is released to farmers depending on their specific conditions.

"Ultimately, this investigation calls for more focused interdisciplinary research efforts to better understand, predict and mitigate the complex effects of atmospheric drying on ecosystems and food security," Sadok and Way said.

The research was funded by grants from the Minnesota Wheat Research & Promotion Council, the Minnesota Soybean Research and Promotion Council and the Minnesota Department of Agriculture.

SCIENTISTS DEVELOP DEVICE TO 'COMMUNICATE' WITH PLANTS USING ELECTRICAL SIGNALS

A team of scientists led by Nanyang Technological University, Singapore (NTU Singapore) has developed a device that can deliver electrical signals to and from plants, opening the door to new technologies that make use of plants.

The NTU team developed their plant 'communication' device by attaching a conformable electrode (a piece of conductive material) on the surface of a Venus flytrap plant using a soft and sticky adhesive known as hydrogel. With the electrode attached to the surface of the flytrap, researchers can achieve two things: pick up electrical signals to monitor how the plant responds to its environment, and transmit electrical signals to the plant, to cause it to close its leaves.

Scientists have known for decades that plants emit electrical signals to sense and respond to their environment. The NTU research team believe that developing the ability to measure the electrical signals of plants could create opportunities for a range of useful applications, such as plant-based robots that can help to pick up fragile objects, or to help enhance food security by detecting diseases in crops early.

However, plants' electrical signals are very weak, and can only be detected when the electrode makes good contact with plant surfaces. The hairy, waxy, and irregular surfaces of plants make it difficult for any thin-film electronic device to attach and achieve reliable signal transmission.

To overcome this challenge, the NTU team drew inspiration from the electrocardiogram (ECG), which is used to detect heart abnormalities by measuring the electrical activity generated by the organ.

Transmitting electrical signals to create an on demand plant-based robot

As a proof-of concept, the scientists took their plant 'communication' device and attached it to the surface of a Venus flytrap -- a carnivorous plant with hairy leaf-lobes that close over insects when triggered.

The device has a diameter of 3 mm and is harmless to the plant. It does not affect the plant's ability to perform photosynthesis while successfully detecting electrical signals from the plant. Using a smartphone to transmit electric pulses to the device at a specific frequency, the team elicited the Venus flytrap to close its leaves on demand, in 1.3 seconds.

The researchers have also attached the Venus flytrap to a robotic arm and, through the smartphone and the 'communication' device, stimulated its leaf to close and pick up a piece of wire half a millimetre in diameter.

Their findings, published in the scientific journal Nature Electronics in January, demonstrate the prospects for the future design of plant-based technological systems, say the research team. Their approach could lead to the creation of more sensitive robot grippers to pick up fragile objects that may be harmed by current rigid ones.

Picking up electrical signals to monitor crop health monitoring

The research team envisions a future where farmers can take preventive steps to protect their crops, using the plant 'communication' device they have developed.

Lead author of the study, Chen Xiaodong, President's Chair Professor in Materials Science and Engineering at NTU Singapore said: "Climate change is threatening food security around the world. By monitoring the plants' electrical signals, we may be able to detect possible distress signals and abnormalities. When used for agriculture purpose, farmers may find out when a disease is in progress, even before full-blown symptoms appear on the crops, such as yellowed leaves. This may provide us the opportunity to act quickly to maximise crop yield for the population."

Prof Chen, who is also Director of the Innovative Centre for Flexible Devices (iFLEX) at NTU, added that the development of the 'communication' device for plants monitoring exemplifies the NTU Smart Campus vision which aims to develop technologically advanced solutions for a sustainable future.

Next generation improvement: Liquid glue with stronger adhesive strength

Seeking to improve the performance of their plant 'communication' device, the NTU scientists also collaborated with researchers at the Institute of Materials Research and Engineering (IMRE), a unit of Singapore's Agency for Science, Technology and Research (A*STAR).

Results from this separate study, published in the scientific journal Advanced Materials in March, found that by using a type of hydrogel called thermogel -- which gradually transforms from liquid to a stretchable gel at room temperature -- it is possible to attach their plant 'communication' device to a greater variety of plants (with various surface textures) and achieve higher quality signal detection, despite plants moving and growing in response to the environment.

Elaborating on this study, co-lead author Professor Chen Xiaodong said, "The thermogel-based material behaves like water in its liquid state, meaning that the adhesive layer can conform to the shape of the plant before it turns into a gel. When tested on hairy stems of the sunflower for example, this improved version of the plant 'communication' device achieved four to five times the adhesive strength of common hydrogel and recorded significantly stronger signals and less background noise."

Co-lead author of the Advanced Materials study and Executive Director of IMRE, Professor Loh Xian Jun, said: "The device can now stick to more types of plant surfaces, and more securely so, marking an important step forward in the field of plant electrophysiology. It opens up new opportunities for plant-based technologies."

Journal Reference:

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NEW FUNGICIDES ANSWER GROWER WISH LIST

THE launch of two new, exciting fungicides for use in canola and cereal crops during the 2021 broadacre cropping season is set to tick a lot of boxes for growers across the country.

They can look forward to additional options for controlling diseases and assisting disease resistance management; flexibility of treatment timings; and, critically, crop safety in mixes with various other protection and input products, allowing convenient, one-pass applications and further enhancing disease control and resistance management.

ADAMA Australia has introduced both Maxentis® EC and Proviso® fungicides to the local industry for use in canola, wheat, barley and oat crops this season. The two new products add to one of the most extensive fungicide ranges in the industry, tackling diseases in all major broadacre crop types.

Maxentis is a unique co-formulation of two of the world's most effective fungicides, prothioconazole and azoxystrobin. As a Group 3 and 11, dual mode of action fungicide, it provides improved disease control spectrum, efficacy and resistance management, as well as an important rotation option following commonly used in-furrow and seed treatment fungicides.

Maxentis can be applied safely at various crop stages and with a range of other crop protection and nutrition products with reduced risk of crop damage.

Rapidly absorbed by leaves, it controls key diseases including seedling and upper canopy blackleg and sclerotinia in canola, as well as rusts, powdery mildew, septoria, yellow leaf spot, scald and ramularia in cereals, while it also features Australia's first registered claim for control of physiological leaf spot (PLS) in barley.

Proviso is a novel prothioconazole fungicide featuring ADAMA's unique Asorbital™ technology, which enables enhanced uptake and systemic activity for improved efficacy, compatibility and crop safety.

Prothioconazole has shown to be the most effective demethylation inhibitor (DMI) fungicide for controlling various diseases, including net blotch populations with low and developing levels of resistance. However, rather than simply introducing another prothioconazole fungicide, ADAMA strived to develop an all-new formulation of the proven active ingredient to ensure real and tangible benefits to growers.

Proviso can be used in tank mixes with a range of other crop protection and nutrition products, controlling a broader range of diseases in canola and cereals, including fusarium head blight in wheat, and to assist disease management. It can be ideally applied as the first foliar application following the use of Succinate Dehydrogenase Inhibitor (SDHI) or strobilurin-based fungicides on seed or in-furrow.

ADAMA Australia Portfolio Manager – Fungicides, Matt Sherriff, said the arrival of Maxentis and Proviso fungicides would take the headache out of disease management for many canola and cereal growers.

Matt said research had confirmed Maxentis offered better crop safety than existing benchmark fungicides whether applied alone or in tank mixes, and it was a similar story for Proviso with its unique formulation.

"Growers will be aware of crop safety and mixing issues when tank mixing various crop protection and nutrition products. Maxentis and Proviso are safer formulations for applications in mixtures, allowing growers to cover their crops in one pass," Matt said.

"Compared with using other fungicides, they will have more flexibility than they have had before to go with various tank mixes from an early stage."

He said Maxentis was one of the few fungicides registered for use in canola containing azoxystrobin and it could be included with top-up applications of herbicides like atrazine as early as the four to six-leaf crop growth stage, as could Proviso.

"This is when a lot of blackleg is coming in and developing resistance to both seed variety genetics and seed treatment fungicides."

Maxentis can be applied through to the flag leaf stage in cereals and Matt said it would be particularly valuable as an alternative mode of action group in cases where SDHI fungicide already had been applied on seed or in-furrow.

In oats, he said the azoxystrobin component could offer potential greening benefits, while the fungicide's mixing capability and rapid absorption would be strongly welcomed.

Matt said Proviso was a more cost-effective and adaptable fungicide, and, to enhance its effectiveness, could be applied with a host of tank mix partners, many of which are conveniently listed on the product label.

He said growers could also have confidence in the knowledge that even where resistance may be developing to any triazoles, prothioconazole was the most effective of these fungicides and by using Proviso, they could avoid paying for additional active ingredients that may now be less effective.

Maxentis and Proviso fungicides were recently included in 30 trials across the country, where they demonstrated their mixing capability with numerous products, crop safety and effectiveness against all major diseases compared with existing standards.

For further information on the new Maxentis and Proviso fungicides, growers can contact their local ADAMA Australia representative, sales agent or visit ADAMA.com.

Fungicides, Matt Sherriff, says new Maxentis and Proviso fungicides will take the headache out of disease management for many canola and cereal growers.

THE NEW SPECIES OF BACTERIA KILLING PALMS IN AUSTRALIA

The bacterium, which they named Candidatus Phytoplasma dypsidis was found to cause a fatal wilt disease. This new discovery was reported in the International Journal of Systematic and Evolutionary Microbiology.

In 2016, several ornamental palms within a conservatory in the Cairns Botanic Gardens, Queensland, died mysteriously. A sample was taken from one of the diseased plants and investigated by Dr Richard Davis and colleagues from the Australian Government Department of Agriculture, Water and the Environment, and state and local government. They compared the characteristics and genome of the bacterium identified as the cause of the disease and found the bacterium was similar to other species of Candidatus Phytoplasma, many of which are responsible for disease epidemics in palms elsewhere but was different enough to be an independent species. "When the laboratory testing indicated it was something close to, but not the same as, devastating palm pathogens overseas, we were very surprised," said Dr Davis.

"At first we thought it was most likely an unrelated fungal disease. Almost as an afterthought, I suggested we screen for phytoplasma because there are some very bad phytoplasma diseases of palms moving around the world, including in neighbouring Papua New Guinea," he explained.

So far, infection with Candidatus Phytoplasma dypsidis has been found to cause disease in 12 different species of palms, including Cocos nucifera, which produces coconuts. "Although palms are not grown as a cash crop in Australia, they are important ornamental garden and amenity plants. Coconuts and other palms are an economically significant component of Australia's tourism industry in the tropics," said Dr Davis.

'Palms take on a much greater significance in most of the countries near Australia, in south east Asia and the Pacific, where coconuts are 'the tree of life'. It is important to raise awareness of a new disease threat, such as this, so that regional biosecurity measures can be prioritised."

The bacterium is thought to be spread from plant-to-plant by insects which feed on phloem, the tissue which transports nutrients around the plant, said Dr Davis: "it seems certain from our observations of how this thing has spread through the local area, that there must be an insect vector. Finding out what vector species are involved is a vital next research priority."

Outbreaks of exotic plant pathogens in Australia are rare due to the country's stringent biosecurity measures. "Australia, New Zealand and the Pacific island countries and territories have an enviable plant and animal health status compared to much of the rest of the world. Because we are islands, we have escaped many significant plant disease threats that have travelled around the world, over history," explained Dr Davis, "As biosecurity plant pathologists for the Australian Government Department of Agriculture, Water and the Environment, our team's main role is to look out for and detect incursions of exotic plant pathogens. We usually do this in remote parts of Australia's north, so to come across something much closer to home in the suburbs of Cairns, in far North Queensland, Australia, was unusual. However, we have no evidence to suggest this is an incursion from overseas because it is a unique organism. It may well be indigenous to Australia and some as yet unknown factor has triggered a disease outbreak."

Dr Davis is concerned that this new disease could spread outside of Cairns and affect palm populations further north: "North of Cairns, we have threatened ecological communities of fan palms which are of great environmental significance," he said. It is important for Dr Davis and his team to continue to monitor the spread of Candidatus Phytoplasma dypsidis. A number of questions remain, including which insect vectors are spreading the disease, and whether the bacterium is capable of infecting other types of plant, including important crops such as bananas.

BETTER, FASTER, SMARTER CROP VARIETY DATA FOR NATION'S GRAIN GROWERS

Australian grain growers are set to get better crop variety recommendations faster through a major Grains Research and Development Corporation (GRDC) international collaborative investment.

The $5.39 million five-year INVITA (Innovations in Variety Testing in Australia) investment will deliver improved predictors of variety performance, quicker access to trial data for growers, better monitoring of trial quality and variety responses to environmental stresses – underpinning greater grower profitability.

GRDC Senior Manager Enabling Technologies, Tom Giles, says INVITA will add value to the GRDC's flagship National Variety Trials (NVT) program by further enhancing the quality and timeliness of NVT varietal performance data.

"Knowing the likely performance of varieties under various environmental conditions will provide growers with more confidence in their crop variety decision making," Mr Giles says.

"The NVT program is a huge logistical undertaking – it is the one of the largest co-ordinated field trial networks of its kind in the world. The INVITA investment adds value to historical NVT data and introduces new technologies and analysis methods to ensure that the NVT program remains at the forefront of variety testing."

Mr Giles says the GRDC investment is being undertaken in partnership with laboratories in Europe where there has been significant investment in the systematic development of remote sensing, imaging technology and data analytics to monitor and predict crop performance through the Horizon 2020 Innovations in Plant Variety Testing in Europe (INVITE) program.

"The Australian initiative is leveraging advances being made within the INVITE program. We are utilising cutting-edge technologies, techniques and capabilities from across the globe to give Australian grain growers the most dynamic, informative, timely and robust data so they can select with confidence the most appropriate varieties for their farming systems and unique environmental conditions."

The five-year INVITA investment will deliver improved predictors of variety performance, quicker access to trial data for growers, better monitoring of trial quality and variety responses to environmental stresses - underpinning greater grower profitability. Photo: The University of Queensland

Leading the INVITA research at The University of Queensland is Professor Scott Chapman, who has long-standing ties with a key INVITE partner, Wageningen University in the Netherlands, the top-ranked university in the world for agricultural research. Australia's leading agriculture research agency, CSIRO, is the other major collaborator.

Professor Chapman, who discusses the investment in a new GRDC video, available at https://bit.ly/3aXOvna, says INVITA embraces the use of drones, satellite images and paddock-based sensors and cameras, with experts in statistics, simulation modelling, machine learning, crop physiology/phenotyping and satellite imaging involved.

"The crop monitoring technology will focus on capturing data on environmental conditions in addition to crop growth, yield and health characteristics," Professor Chapman says.

"That will aid us in developing analytical tools capable of predicting crop performance in ways that account for impacts from environmental variables within trials – moving the science closer to being able to extend predictions to farms."

INVITA commenced with field trials focused on bread wheat varieties, and other crop types will be considered for inclusion this year. In the European project, data is also being captured for canola, maize and sunflowers.

"In 2020, 90 wheat field sites across Australia hosted the remote-sensing technology," Professor Chapman says. "Included were a subset of about 50 NVT locations which were selected to host ancillary trials."

The ancillary trials fall under two classes: BioCal and SatCal sites. The SatCal sites include satellite data collection to provide a constant point on Earth to align the satellite images with NVT trials.

The BioCal (short for biomass calibration trial) sites involve six different wheat types (sourced from the NVT) planted at different densities and sampled three times during the season. All trials at these sites were imaged using drones equipped with RGB (standard red-green-blue cameras) or with multispectral cameras that include NIR (near infra-red) and NRE (near red edge) wavelengths to match with satellite imaging. The drone data is being processed to generate detailed field maps at less than one-centimetre resolution.

In addition, the BioCal sites include fixed 4G cameras that transmit single-plot images four times a day, canopy temperature sensors and, at a few sites, Arable Mark weather station/reflectance sensors.

Three trial sites managed by The University of Queensland, CSIRO and the South Australian Research and Development Institute (the research division of the SA Department of Primary Industries and Regions) were also subject to more intensive in-season crop performance assessment (or phenotyping) than the NVT sites.

Examples of the new capabilities include software that uses drone-derived or smartphone data to estimate early crop cover or count wheat heads or, alternatively, uses satellite images and drone-derived imagery to estimate leaf area and biomass. These estimates can then be run against environmental conditions and other data to mine deeper correlations.

Along the way, project activities are helping to upskill NVT Service Providers in the use of remote sensing technology. As this becomes established technology, the broader agricultural research community also stands to benefit through the commercial availability of services for steady streams of paddock-relevant data.

"The strength of INVITE and INVITA's approach is the ability to integrate the satellite, drone and observational data while advancing the ability to extract useful information from images," Professor Chapman says.

"The result is an integrated platform that allows a new understanding about the way varieties and environments interact that will prove especially useful when analysing performance of varieties in the NVT trials."

A new podcast detailing the investment is available at http://bit.ly/2Of3TUz. More information about the INVITA investment can also be found in a GRDC Ground Cover story at https://bit.ly/3ui622m.

INVITA embraces the use of drones, satelite images and paddock-based sensors and cameras. Photo: The University of Queensland.

THE BACTERIA THAT LOOK AFTER US AND THEIR PROTECTIVE WEAPONS

Patricia Bernal, a Ramón y Cajal researcher at the Department of Microbiology of the University of Seville's Faculty of Biology, is working with the bacterium Pseudomonas putida, a biological control agent found in the soil and in plant roots and which, as such, has the ability to protect plants from pathogen attacks (organisms that cause diseases) also known as phytopathogens. Specifically, the US researcher is studying a molecular weapon that bacteria use (Type VI Secretion System or T6SS) to eliminate their competitors.

The T6SS could be compared to a harpoon with a poisonous tip that bacteria throw at their enemies to annihilate them. In a recent paper, which has just been published in the scientific journal PNAS and for which Patricia Bernalworked with researchers from Imperial College London (UK) and the University of Texas at Austin (USA), the authors describe a new assembly model of this bacterial machinery that allows it to be articulated very quickly and triggered instantaneously.

Knowledge of this protection mechanism at the molecular level is essential to optimise the biocontrol processes that will enable us to transition towards more sustainable agriculture.

"Microorganisms have the answer to reconcile humans with nature. Among other things, biocontrol agents will allow us to move towards a form of agriculture that respects the environment and the health of animals and people," says Bernal.

In a previous study, the US researcher already described the T6SS as one of the key mechanisms used by P. putida to eliminate phytopathogens and for crop protection.

UNIFORM DRYING TIME FOR GOLDENSEAL TO ENHANCE MEDICINAL QUALITIES OF FOREST HERB

Developing a standardised drying protocol for goldenseal could lead to more predictable health applications and outcomes by preserving the alkaloids found in the plant, which is native to Appalachia, according to Penn State researchers, who conducted a new study of the medicinal forest herb.

The roots and rhizomes of goldenseal -- Hydrastis canadensis -- have been used for hundreds of years as a source of antimicrobials and compounds to treat intestinal ailments, noted study co-author Eric Burkhart, associate teaching professor, ecosystem science and management.

"Three alkaloids -- berberine, hydrastine and canadine -- are recognised as the major bioactive constituents in goldenseal," said Burkhart, who also is program director, Appalachian botany and ethnobotany, at Shaver's Creek Environmental Centre.

"One important postharvest processing step for goldenseal is drying. However, before this study it was not known how drying temperature influences the concentrations of these alkaloids."

To investigate this question, researchers removed goldenseal samples from three plant colonies within a wild population located in central Pennsylvania. Fourteen "ramets," or bunches, were harvested from each plot in early April while plants were dormant.

Lead researcher Grady Zuiderveen, doctoral student in ecosystem science and management, freeze-dried or air-dried goldenseal samples at six temperatures, ranging from 80 to 130 degrees Fahrenheit, to determine the relationship between drying temperature and alkaloid content in the rhizome and roots.

In findings recently published in Hortscience, high performance liquid chromatography analysis showed that berberine and hydrastine levels were unaffected by drying temperature, while canadine levels decreased as temperature increased. On average, the level of canadine dropped by slightly more than half when samples were freeze-dried and fell by nearly a third when dried at 130 F.

While canadine is the least abundant alkaloid of the three, it is known to have key antibacterial properties, Zuiderveen pointed out, so developing a more standardised drying protocol for goldenseal could lead to a more predictable phytochemical profile.

"This work is important because canadine has been found to have significant activity against numerous strains of bacteria, and in previous research it was the only one of the three major alkaloids found to be active against Pseudomonas aeruginosa and Staphylococcus aureus," he said. "Also, canadine possesses significant antioxidant properties and has been identified as effective at strengthening the immune system."

Goldenseal, native to the forests of Appalachia, is a medicinal herb. Its roots and rhizomes have been used for hundreds of years as a source of antimicrobials and compounds to treat intestinal ailments. **CREDIT:** Eric Burkhart/Penn State

INVASIVE WEED MAY HELP TREAT SOME HUMAN DISEASES, RESEARCHERS FIND

Native to the southeastern United States, a weedy grass has spread northward to Canada and also made its way to Australia and Japan. Andropogon virginicus grows densely packed and up to seven feet tall, disrupting growth patterns of other plants and competing for resources. When burned, it grows back stronger. There is no way to effectively remove the weed once it has invaded. But there might be a way to use it to human advantage.

An international team of researchers has found that A. virginicus extracts appear to be effective against several human diseases, including diabetes and cancer. The results were published on Dec. 31, 2020, in a special issue of Plants, titled "Biological Activities of Plant Extracts."

"A. virginicus is an invasive weed that seriously threatens agricultural production and economics worldwide," said paper author Tran Dang Xuan, associate professor in the Transdisciplinary Science and Engineering Program in the Graduate School of Advanced Science and Engineering at Hiroshima University. "However, no solution efficiently utilising and tackling this plant has been found yet. In this paper, we highlight the potential application of A. virginicus extracts in future medicinal production and therapeutics of chronic diseases such as type 2 diabetes and blood cancer, which can deal with both crop protection and human health concerns."

Researchers found high levels of flavonoids in the samples they extracted from the weed. These plant chemicals have significant antioxidant and anti-inflammatory properties, according to Xuan. When tested against a variety of cell lines, the extracted plant chemicals bonded to free radicals, preventing damage to the cells. At skin level, this helps prevent age spots by inhibiting a protein called tyrosinase. Among other, deeper healthful actions, this bonding also helps prevent knock-on cellular actions that can lead to type 2 diabetes.

The team also specifically applied the extracted chemicals to a line of chronic myelogenous leukemia, a rare blood cancer. The extract appeared to kill off the cancer cells.

Xuan said the researchers plan to establish a comprehensive process to isolate and purify the compounds responsible for known biological properties, as well as work to identify new uses. They will further test the therapeutical effects of the compounds, with the eventual goal of preparing functional pharmaceuticals for human use.

"Although A. virginicus has been considered a harmful invasive species without economic value, its extracts are promising sources of antioxidant, anti-diabetic, anti-tyrosinase, and antitumor agents," Xuan said.

SCIENTISTS STUDY CO-EVOLUTIONARY RELATIONSHIP BETWEEN RUST FUNGI AND WHEAT AND BARBERRY

Wheat stripe rust is one of the most important wheat diseases and is caused by the plant-pathogenic fungi Puccinia striiformis f. sp. tritici (Pst). Though Pst is known to be highly host-specific, it is interestingly able to infect two unrelated host plants, wheat and barberry, at different spore stages. Pst infects wheat through its urediniospores and infects barberry with its basidiospores.

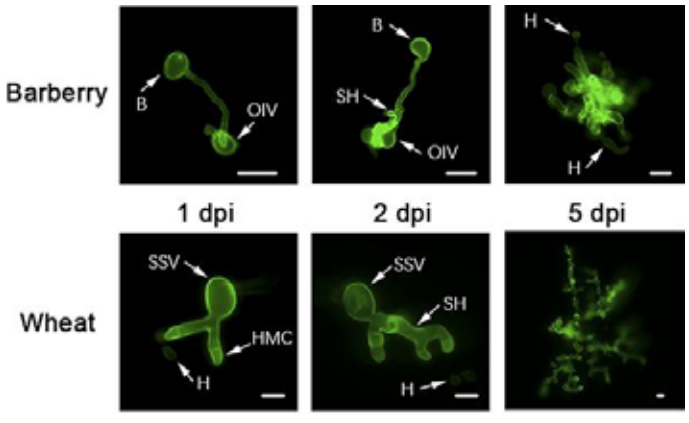
"This complex life cycle poses interesting questions on the co-evolution between the pathogen and the hosts, as well the different mechanisms of pathogenesis underlying the infection of the two different hosts," explained Jing Zhao, an associate research fellow at the College of Plant Protection at Northwest A & F University in China.

In a recent study, Zhao and colleagues studied the co-evolutionary relationship between rust fungi and its hosts using genes specifically needed for the host infection at different spore stages. They comprehensively compared the transcriptomes of Pst during the infection of wheat and barberry leaves and were able to identify the genes needed for either wheat or barberry infection and the genes needed to infect both. They found a larger proportion of evolutionarily conserved genes in barberry, implying a longer history of interaction with Pst.

"As a matter of fact, the barberry family, belonging to primitive angiosperms and originating from 146-113 million years ago, is evolutionarily older than grasses, which means it interacted with rust fungi earlier. Thus, we postulated a hypothesis that barberry might be the primary host of Pst," said Zhao.

Zhao pointed out that Pst cleverly applies distinct strategies to overcome various host defense systems. For example, the fungi are able to secrete different sets of enzymes to degrade different types of cell walls and cuticles based on perception of different chemical components.

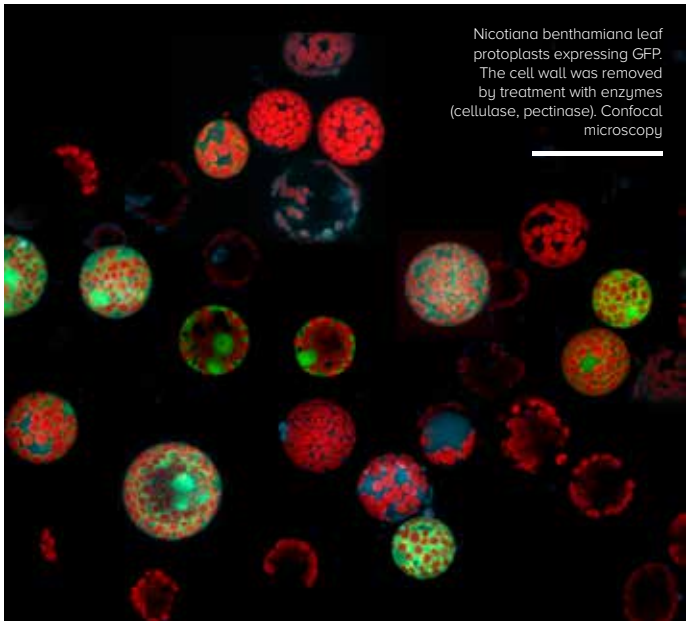
Their work will contribute to a deeper understanding of the roles of barberry in wheat rust disease and sustainable control of stripe rust disease. It also provides a model to understand the evolutionary processes and strategies of different stages of a pathogen during the infection process on different hosts. Read more about this study in "Distinct Transcriptomic Reprogramming in the Wheat Stripe Rust Fungus During the Initial Infection of Wheat and Barberry" published in the MPMI journal.



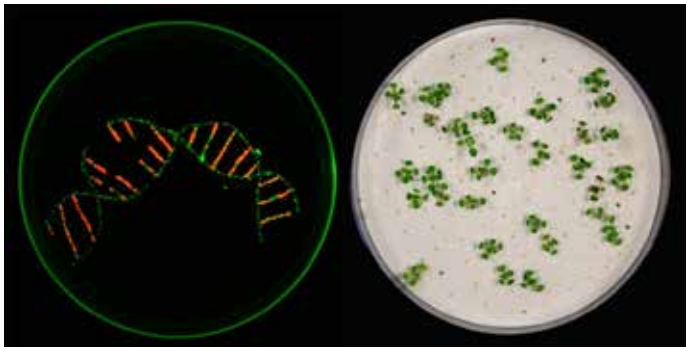
Infection processes of Puccinia striiformis f. sp. tritici basidiospores and urediniospores on barberry and wheat. **CREDIT:** Jing Zhao

UPGRADE FOR CRISPR/CAS: RESEARCHERS KNOCK OUT MULTIPLE GENES IN PLANTS AT ONCE

Tobacco plantation



Nicotiana benthamiana leaf protoplasts expressing GFP. The cell wall was removed by treatment with enzymes (cellulase, pectinase). Confocal microscopy



In their work, the researchers used markers to distinguish between different plant seeds. No difference can be seen with the naked eye. Under UV light, however, transgenic seeds appear red, non-transgenic seeds green. (left picture) **CREDIT:** Jessica Lee Erickson

Using an improved version of the gene editing tool CRISPR/Cas9, researchers knocked out up to twelve genes in plants in a single blow. Until now, this had only been possible for single or small groups of genes. The approach was developed by researchers at Martin Luther University Halle-Wittenberg (MLU) and the Leibniz Institute of Plant Biochemistry (IPB). The method makes it easier to investigate the interaction of various genes. The study appeared in The Plant Journal.

The inheritance of traits in plants is rarely as simple and straightforward as Gregor Mendel described. The monk, whose experiments in the 19th century on trait inheritance in peas laid the foundation of genetics, in fact got lucky. "In the traits that Mendel studied, the rule that only one gene determines a specific trait, for example the colour of the peas, happened to apply," says plant geneticist Dr Johannes Stuttmann from the Institute of Biology at MLU. According to the researcher, things are often much more complicated. Frequently there are different genes that, through their interaction with one another, result in certain traits or they are partly redundant, in other words they result in the same trait. In this case, when only one of these genes is switched off, the effects are not visible in the plants.

The scientists at MLU and IPB have now developed a way to study this complex phenomenon in a more targeted way by improving CRISPR/Cas9. These gene editing tools can be used to cut the DNA of organisms at specific sites. The team built on the work of biologist Dr Sylvestre Marillonnet who developed an optimised building block for the CRISPR/Cas9 system at the IPB.

"This building block helps to produce significantly more Cas9 enzyme in the plants, which acts as a scissor for the genetic material," explains Stuttmann.

The researchers added up to 24 different guide RNAs which guide the scissor enzyme to the desired locations in the genetic material. Experiments on thale cress (Arabidopsis thaliana) and the wild tobacco plant Nicotiana benthamiana proved that the approach works. Up to eight genes could be switched off simultaneously in the tobacco plants while, in the thale cress, up to twelve genes could be switched off in some cases. According to Stuttmann, this is a major progress: "As far as I know, our group has been the first to successfully address so many target genes at once. This may make it possible to overcome the redundancy of genes," says the biologist.

Until now, creating multiple mutations was a much more complex process. The plants had to be bred in stages with a single mutation each and then crossed with one another. "This is not only time-consuming, it's also not possible in every case," says Stuttmann. The new approach developed at the MLU and the IPB overcomes these disadvantages and could prove to be a more efficient method of research. In future, it will also be possible to test random combinations of several genes in order to identify redundancies. Only in the case of conspicuous changes in the plant's traits would it then be necessary to specifically analyse the genetic material of the new plants.

PLANTS WOULD GROW WELL IN SOLAR CELL GREENHOUSES

A recent study shows that lettuce can be grown in greenhouses that filter out wavelengths of light used to generate solar power, demonstrating the feasibility of using see-through solar panels in greenhouses to generate electricity.

"We were a little surprised -- there was no real reduction in plant growth or health," says Heike Sederoff, co-corresponding author of the study and a professor of plant biology at North Carolina State University. "It means the idea of integrating transparent solar cells into greenhouses can be done."

Because plants do not use all of the wavelengths of light for photosynthesis, researchers have explored the idea of creating semi-transparent organic solar cells that primarily absorb wavelengths of light that plants don't rely on, and incorporating those solar cells into greenhouses. Earlier work from NC State focused on how much energy solar-powered greenhouses could produce. Depending on the design of the greenhouse, and where it is located, solar cells could make many greenhouses energy neutral -- or even allow them to generate more power than they use.

But, until now, it wasn't clear how these semi-transparent solar panels might affect greenhouse crops.

To address the issue, researchers grew crops of red leaf lettuce (Lactuca sativa) in greenhouse chambers for 30 days -- from seed to full maturity. The growing conditions, from temperature and water to fertiliser and CO2 concentration, were all constant -- except for light.

A control group of lettuces was exposed to the full spectrum of white light. The rest of the lettuces were dived into three experimental groups. Each of those groups was exposed to light through different types of filters that absorbed wavelengths of light equivalent to what different types of semi-transparent solar cells would absorb.

"The total amount of light incident on the filters was the same, but the colour composition of that light was different for each of the experimental groups," says Harald Ade, co-corresponding author of the study and the Goodnight Innovation Distinguished Professor of Physics at NC State.

"Specifically, we manipulated the ratio of blue light to red light in all three filters to see how it affected plant growth," Sederoff says.

To determine the effect of removing various wavelengths of light, the researchers assessed a host of plant characteristics. For example, the researchers paid close attention to visible characteristics that are important to growers, grocers and consumers, such as leaf number, leaf size, and how much the lettuces weighed. But they also assessed markers of plant health and nutritional quality, such as how much CO2 the plants absorbed and the levels of various antioxidants.

"Not only did we find no meaningful difference between the control group and the experimental groups, we also didn't find any significant difference between the different filters," says Brendan O'Connor, co-corresponding author of the study and an associate professor of mechanical and aerospace engineering at NC State.

"There is also forthcoming work that delves into greater detail about the ways in which harvesting various wavelengths of light affects biological processes for lettuces, tomatoes and other crops," Sederoff says.

"This is promising for the future of solar-powered greenhouses," Ade says. "Getting growers to use this technology would be a tough argument if there was a loss of productivity. But now it is a simple economic argument about whether the investment in new greenhouse technology would be offset by energy production and savings."

"Based on the number of people who have contacted me about solar-powered greenhouses when we've published previous work in this space, there is a lot of interest from many growers," O'Connor says. "I think that interest is only going to grow. We've seen enough proof-of-concept prototypes to know this technology is feasible in principle, we just need to see a company take the leap and begin producing to scale."

The work was done with support from the National Science Foundation under grants 1639429 and 1905901; the Office of Naval Research, under grants N00014-20-1-2183, N00014-17-1-2242 and N00014-17-1-2204; North Carolina State University; and NextGen Nano Limited.

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A KNOCKDOWN THAT IS SO GRANULAR

A new granular combination product from Kenso Agcare that combines glyphosate & dicamba is known as KOKAMBA. It offers increased killing power across a broader spectrum of weeds than glyphosate alone. It has more power to control broadleaf weeds such as Capeweed, Volunteer legumes, Hogweed, Sorrel, thistles and other cruciferous weeds.

Combining 541g/kg Glyphosate & 105g/kg Dicamba, it is ideal for pre-sowing knockdown application as it has short plant-back periods of 1-21 Days, compared to other glyphosate + spike applications. Plant-back periods for cereals are 1-7 Days, canola 7-10 Days & legumes 7-21 Days depending on rate applied.

It's all about offering convenience of an all-in-one granule, meaning no spilling of liquids and no mistakes when measuring spike herbicides. The convenient 15kg bag improves ease of use of the product while reducing packaging bulk and disposal requirements.

Steve Cameron, Kenso Agcare Regional Sales Manager Vic/Tas, says his customers have been really impressed with the performance of KOKAMBA. "I have customers and their farmers telling me they are really happy with the results. They love the convenience of the combined granule." Andrew McMahan – Agronomist Nutrien Ag Solutions Manangatang states, "we use quite a lot of dicamba over Summer for fallow spraying and we have been extremely happy with the results of KOKAMBA. It is a cost-effective option that allows growers to spray paddocks for a similar cost as buying bulk volumes, while only having to buy smaller pack sizes".

Like its stable partner KEN-UP DRY 680, KOKAMBA utilises the mono-ammonium salt of glyphosate and shares performance characteristics like fast brownout and consistency of results in tough conditions.

UNIQUE CROP PEST MONITORING SOLUTION BRINGS MULTIPLE BENEFITS

The ADAMA Trapview Predictive Pest Network was launched last year as part of the company's ongoing push to provide Australian growers and agronomists with the latest AgTech solutions to help drive improved productivity.

The integrated network of smart insect traps, the first of its kind in Australia for predicting pest pressures, comprised more than 500 remote traps monitoring major insects across key growing regions of the country.

The Trapview technology operates by capturing images and providing digital recognition of lured pests, allowing near real-time monitoring of pest movements across large areas. The images are captured daily and then archived using a cloud-based system.

Network subscribers not only receive information from within their region, including rapid pest alerts, but also State-based pest pressure for the particular network subscribed to. They receive daily and weekly email reports detailing pest detection, movement and development stages. Results also can be accessed by desktop and mobile devices using the Trapview App.

ADAMA Australia AgTech and Innovation Manager Andrew Newall said subscriber numbers to the different networks across the country last year were above the company's expectations and feedback was overwhelmingly positive.

"The networks saved agronomists a lot of time around their monitoring for pests, generally of two to three weeks," Andrew said.
"Normally, the season would get to a certain time and after favourable conditions for pests, they would start sweeping crops. However, with Trapview they could wait, understand when pest numbers started and the pressure the networks were indicating, and then start monitoring.
"The pressure doesn't happen in a wave. There can be hotspots and then a general infestation later.
"The information provided agronomists with greater visibility on what pest pressures were occurring when and related to which crop type, allowing them to put a strategy around monitoring and the particular control option selected and time of application. This could also include mixing with a fungicide, so it allowed them to refine their management a little."

He said the beauty with Trapview was that the information could be aligned with the results from sweeping in the field.
"Etiella is unique to lentil crops and is generally hard to control, with the aim to spray moths quickly as they land, before they lay eggs. Once the larvae hatch, they burrow into pods, so you want to deter moths from flying into crops," Andrew said.

Brett Douglas, a Director of the Driscoll Ag, said the local Trapview network had changed pest spraying practice in the area from traditionally being reactive to proactive.

He said lentils, faba beans and chickpeas were the main crops in the region affected by insects, so the addition of etiella pheromones to the smart traps for this season would significantly benefit early control of the pest. Trapview last season also assisted with management decisions in canola crops that typically would not be sprayed.
"There was quite a number of traps to the north-west that give us a real good indication of when heliothis would hit, and now with etiella being added it will be brilliant," Brett said.

"Being proactive with grub spraying is what you want to be, because they can do a lot of damage quickly.
"The information gives you a heads-up and growers become aware that moths are on their way and about to lay eggs, so they can get out there and spray.

"It's like precision ag and that is what the modern farmer is looking for. It gives us the edge to be in front of the game. It's innovative and we need to have that at our fingertips to make better decisions."

He said the network certainly saved significant monitoring time and while crop sweeps were still carried out to ensure the information was correct, it was more accurate than sweeping, which provided good confidence and they would now base their pest management decisions on Trapview.

"It's fantastic. If it can save us time and bring a better end result, then that's a great improvement."

"It was really good with our clients looking at the data. Growers would come into the store in the morning to have a look at the Trapview information – so we have gone from using the net to using the internet," he quipped.
"Other staff also took a lot of interest and then shared the information with other grower customers."

Brett said he believed the results of Trapview last season also

Etiella, a hard-to-control insect unique to lentil crops, is being added to ADAMA's 150-plus smart trap predictive pest network across South Australia and Victoria for this season

A smart insect trap installed in a faba bean crop as part of the ADAMA Trapview Predictive Pest Network

contributed to minimal grain damage for growers at harvest. "There has been plenty of times where I have seen beans with problems, but last year was the best quality grain I have seen in my lifetime."

Matt Beddison, of Crop Opti Services at Horsham, said instead of conducting crop sweeps, relying on pest information from other branches and making educated decisions, the daily Trapview reports saved a lot of time and allowed more accurate and effective management decisions.

"We were still doing sweeps to ground-truth the information, but it was quite accurate. The beauty of the system is knowing exactly where the moths are. Flight reports daily track where they are going, it tells us the stage grubs are at and you also get an understanding of what crops they are in, whether it's beans, lentils or canola, and which to target first," Matt said.
"The traps can also pick up secondary flights if it takes crops longer to mature and so getting a time saving on the back end as well, by not going back to sweep, can allow you to focus on other things like fungicide applications."

He said based on the performance of Trapview last year, when 10-12 traps were used in an area within 50 kilometres of Horsham, Crop Opti Services was "100 per cent confident" in its monitoring results.

"You can be more accurate with real-time data. Instead of saying 'I think we should spray now', the traps can say 'yep, we have got grubs, spray now with the right conditions."
"You may not change your chemical decision, but it could help you get the most out of the residual."

Brett said the information was invaluable to pass on to growers and to support advice on protecting their crops as best as possible.

With 60-70pc of pulse production in the area devoted to lentils, he said the addition of etiella to the local ADAMA Trapview network this season would be a major bonus.

"If the traps can detect the moths coming in, making the timing of applications more accurate and relevant, it could save a lot of dollars from damaged lentils."

Andrew Newall, AgTech and Innovation Manager with ADAMA Australia, says the company's Trapview networks save agronomists a lot of time around their monitoring for pests

GO FOR GOLD

KENSO's AVIOR GOLD cereal fungicide is continuing to come out on top against fungal pathogens in Australian wheat and barley crops. The unique formulation combines the curative and protective activity of Epoxiconazole and Azoxystrobin in one lethal package.

Given its dual-mode of activity, AVIOR GOLD Fungicide has curative activity against early stages of many fungal infections and also controls the late season disease complex in cereals when applied from flag leaf emergence. Applications made to crops over the flag leaf to head emergence growth stages will provide significant green leaf area retention that can contribute to yield increases and can control these diseases for up to six-weeks post application.

Epoxiconazole, a Group 3 protective and curative fungicide, works when the infection is more progressed. When applied at this later stage of infection, epoxiconazole inhibits cell membrane biosynthesis in fungal pathogens. This activity takes place when the fungal cell has formed an appressorium and an infection peg is persisting to break into the infected plant's cell wall. Epoxiconazole will prevent this process from occurring by disrupting cell membrane biosynthesis.

Disruption of this biological process will then prevent the infection from persisting into the cell. In combination, these two actives assist to protect and cure infected plants from diseases such as Stripe Rust, Septoria Nodorum Blotch, Leaf Rust, Leaf Scald, Powdery Mildew, Spot Form of Net Blotch and Net Form of Net Blotch.

SHORT-LIVED PLANT SPECIES ARE MORE CLIMATE-SENSITIVE

Plant species with short generation times are more sensitive to climate change than those with long generation times. This is one of the findings of a synthesis study by researchers from the German Centre for Integrative Biodiversity Research (iDiv), the Martin Luther University Halle-Wittenberg (MLU) and the Helmholtz-Centre for Environmental Research (UFZ). The international team comprehensively compiled worldwide available data, mostly from Europe and North America, to address the question of how plant populations react to climate change. The study, published in Nature Communications, shows that plant characteristics such as generation time can predict how sensitive species are to changing climates. This has important implications for predicting which plant species need the most conservation attention regarding climate change.

Climate change is considered to be one of the greatest threats to plant species diversity. To set the right priorities in nature conservation policy, it is crucial to know which regions of the world and which types of species are particularly threatened by climate change.

As part of the iDiv synthesis centre sDiv, which brings together international experts in workshops, a working group compiled all long-term studies on plants that quantify population growth rate. They assessed how the climate factors during those years of study, in particular precipitation and temperature, influenced population growth rate. Afterwards, they tested how features of the plant species, such as the length of a generation, influence how responsive the plant population growth rates were to climate variation in the past.

"We were able to show that generation duration is a useful indicator value for a species' susceptibility to climate change," said first author Dr Aldo Compagnoni, a postdoctoral researcher at iDiv and MLU. For example, the scientists found that especially plants with short lifespans, such as those that only live a few years on average, suffered from climate extremes much worse than long-lived species. The analyses also showed that the main limiting factor of climate change is not the temperature increase itself. On average, precipitation had a three times greater impact on plant populations than temperature.

"This work helps us identify which species might be climate-vulnerable, even if we have limited information about those species," says last author Prof Tiffany Knight from iDiv, MLU and UFZ. For example, while we have long-term population data for a small subset of plant species on Earth, we can estimate the approximate generation duration for most plant species. This is an important first step towards determining species' vulnerability to climate change at a global scale."

However, there are important data gaps that limit the ability to make general predictions on a global scale. The researchers found appropriate long-term datasets only for 62 of the 350,000 plant species on Earth, and the vast majority of these were species occurring in temperate zones of the USA and Western Europe. Apart from a few tree and shrub species, the data set included only grasses and herbs. To be able to make reliable predictions about the consequences of climate change for all regions of the world and all known species, new population ecology research is needed on woody plant species and on plants in the tropics, the researchers conclude.

GHOSTS OF PAST PESTICIDE USE CAN HAUNT ORGANIC FARMS FOR DECADES

Although the use of pesticides in agriculture is increasing, some farms have transitioned to organic practices and avoid applying them. But it's uncertain whether chemicals applied to land decades ago can continue to influence the soil's health after switching to organic management. Now, researchers reporting in ACS' Environmental Science & Technology have identified pesticide residues at 100 Swiss farms, including all the organic fields studied, with beneficial soil microbes' abundance negatively impacted by their occurrence.

Fungicides, herbicides and insecticides protect crops by repelling or destroying organisms that harm the plants. In contrast, organic agriculture management strategies avoid adding synthetic substances, instead relying on a presumably healthy existing soil ecosystem. However, some organic farms are operating on land treated with pesticides in the past. Yet, it's unclear whether pesticides have a long-lasting presence in organically managed fields and what the reverberations are to soil life, specifically microbes and beneficial soil fungi, years after their application. So, Judith Riedo, Thomas Bucheli, Florian Walder, Marcel van der Heijden and colleagues wanted to examine pesticide levels and their impact on soil health on farms managed with conventional versus organic practices, as well as on farms converted to organic methods.

The researchers measured surface soil characteristics and the concentrations of 46 regularly used pesticides and their breakdown products in samples taken from 100 fields that were managed with either conventional or organic practices. Surprisingly, the researchers found pesticide residues at all of the sites, including organic farms converted more than 20 years prior. Multiple herbicides and one fungicide remained in the surface soil after the conversion to organic practices; though the total number of synthetic chemicals and their concentrations decreased significantly the longer the fields were in organic management.

According to the researchers, some of the pesticides alternatively could have contaminated the organic fields by traveling through the air, water or soil from nearby conventional fields. In addition, the team observed lower microbial abundance and decreased levels of a beneficial microbe when fields had higher numbers of pesticides in the fields, suggesting that the presence of these substances can decrease soil health. The researchers say future work should examine the synergistic effects of pesticide residues and other environmental stressors on soil health.

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TECHNIQUE BASED ON ARTIFICIAL INTELLIGENCE PERMITS AUTOMATION OF CROP SEED ANALYSIS

In Brazil, researchers affiliated with the Centre for Nuclear Energy in Agriculture (CENA) and the Luiz de Queiroz College of Agriculture (ESALQ), both part of the University of São Paulo (USP), have developed a methodology based on artificial intelligence to automate and streamline seed quality analysis, a process required by law and currently done manually by analysts accredited with the Ministry of Agriculture.

The group used light-based technology like that deployed in plant and cosmetics analysis to acquire images of the seeds. They then turned to machine learning to automate the image interpretation process, minimising some of the difficulties of conventional methods. For example, for many species, optical imaging technology can be applied to an entire batch of seeds rather than just samples, as is the case currently. Furthermore, the technique is non-invasive and does not destroy the products analysed or generate residues.

The light-based techniques consisted of chlorophyll fluorescence and multispectral imaging. Among plants that are relevant as both crops and experimental models, the researchers chose tomatoes and carrots produced in different countries and seasons and submitted to different storage conditions. They used seeds of the Gaucho and Tyna commercial tomato varieties produced in Brazil and the US, and seeds of the Brasilia and Francine carrot varieties produced in Brazil, Italy, and Chile.

The choice was based on the economic importance of these food crops, for which world demand is high and rising, and on the difficulties faced by growers in collecting their seeds. In both tomatoes and carrots, the ripening process is not uniform because the plants flower continuously and seed production is non-synchronous, so that seed lots may contain a mixture of immature and mature seeds. The presence of immature seeds is not easily detected by visual methods, and techniques based on machine vision can minimise this problem.

The researchers compared the results of their non-destructive analysis with those of traditional germination and vigour tests, which are destructive, time-consuming, and labor-intensive. In the germination test, seed analysts separate samples, sow them to germinate in favourable temperature, water, and oxygen conditions, and verify the final quantity of normal seedlings produced in accordance with the rules established by the Ministry of Agriculture. Vigour tests are complementary and more sophisticated. The most common are based on the seed's response to stress and seedling growth parameters.

Besides the difficulties mentioned, traditional methods are time-consuming. In the case of tomatoes and carrots, for example, it can take up to two weeks to obtain results, which are also largely subjective, depending on the analyst's interpretation.

"Our proposal is to automate the process as much as possible using chlorophyll fluorescence and multispectral imaging to analyse seed quality. This will avoid all the usual bottlenecks," said Clíssia Barboza da Silva, a researcher at CENA-USP and one of the authors of an article on the study published in Frontiers in Plant Science.

Silva is the principal investigator for the project supported by São Paulo Research Foundation - FAPESP. The lead author of the article is Patrícia Galletti, who conducted the study as part of her master's research and won the Best Poster Award in 2019 at the 7th Seed Congress of the Americas, where she presented partial results of the project.

Chlorophyll as a marker of quality

Chlorophyll is present in seeds, where it supplies energy for the storage of nutrients needed for development (lipids, proteins, and carbohydrates). Once it has fulfilled this function, the chlorophyll breaks down. "However, if the seed doesn't complete the maturation process, this chlorophyll remains inside it. The less residual chlorophyll, the more advanced the maturation process and the more and higher-quality the nutrients in the seed. If there's a lot of chlorophyll, the seed is immature and its quality is poor," Silva said.

If light at a specific wavelength is shone on the chlorophyll in a seed, it does not transfer this energy to another molecule but instead re-emits the light at another wavelength, meaning that it fluoresces. This fluorescence can be measured, she explained. Red light can be used to excite chlorophyll and capture the fluorescence using a device that converts it into an electrical signal, producing an image comprising gray, black, and white pixels. The lighter areas correspond to higher levels of chlorophyll, indicating that the seed is immature and unlikely to germinate.

Artificial intelligence

In multispectral imaging, LEDs (light-emitting diodes) emit light in the visible portion of the spectrum as well as non-visible light (UV and near-infrared). To analyse seed quality based on reflectance, the researchers used 19 wavelengths and compared the results with quality assessment data obtained by traditional methods. The best results were obtained using near-infrared in the case of carrot seeds and UV in the case of tomato seeds.

Seeds contain proteins, lipids and sugars that absorb part of the light emitted by the LEDs and reflect the rest. The reflected light is captured by a multispectral camera, and the image captured is processed to separate the seeds from the support in the device, which corresponds to black pixels with zero value, while the seeds are grey-scale. The values of the pixels in the image of a seed correspond to its chemical composition.

"We don't work with an average result for a sample. We perform individualised extraction for each seed," Silva said. "The larger the amount of a given nutrient the seed contains, the more light of a specific wavelength it absorbs so that less is reflected. A seed with a smaller nutrient content contains fewer light-absorbing molecules. This means its reflectance is higher, although this varies according to its components, which behave differently depending on the light wavelength used."

An algorithm identifies the wavelength that obtains the best result. The process provides information about the seed's chemical composition, from which its quality can be inferred.

For the researchers, it was not enough to reach the imaging stage, as this is still an operation that requires human observation. "We then deployed chemometrics, a set of statistical and mathematical methods used to classify materials chemically," Silva said. "The idea was that the equipment should classify quality on the basis of the image it captured." The methods used by the scientists in this study are widely used in medicine and the food industry.

Next, they leveraged machine learning to test the models created using chemometrics. "We taught the model to identify high-quality and low-quality seeds. We used 70% of our data to train the model, and used the remaining 30% for validation," Silva said. Quality classification accuracy ranged from 86% to 95% in the case of tomato seeds, and from 88% to 97% in the case of carrot seeds.

The two main techniques were both accurate and time-saving, given the speed of image capture. The chlorophyll fluorescence instrument captured one image per second, while the multispectral imaging analyser processed 19 images in five seconds.

Unexpected results

An unexpected result produced in the course of the project proved highly important. Chlorophyll fluorescence and multispectral imaging are also efficient techniques for plant variety screening, an essential part of seed lot evaluation to avoid economic losses.

> **"Growers buy seeds with the expectation of a certain crop yield, but production will be affected if seeds with different genetic characteristics aren't properly separated," Silva said.**

Screening is currently done by analysts trained in the skills needed to grade seeds by colour, shape, and size, as well as molecular markers where possible. In the study, both techniques proved efficient to separate carrot varieties but multispectral imaging was unsatisfactory in the case of tomato varieties.

"The study produced novel results with regard to the use of fluorescence to screen varieties," Silva said. "We found no prior research in which fluorescence was used for this purpose. Some studies show multispectral imaging to be efficient for this purpose, but not with the instrument we used."

Instrument sharing

A good way to transfer the knowledge produced by the research to the productive sector, Silva said, would be to have firms develop the equipment for sale to seed producers. "It would be possible to use the results of our research to develop an instrument that used only UV light to characterise tomato seed quality and bring it to market, for example," she surmised.

RESEARCHERS SHOW WHERE AND HOW PLANTS DETECT THE NUTRIENT POTASSIUM

Potassium is an essential nutrient for all living things. Plants need it in large quantities, especially for growth and in order to withstand stress better. For this reason, they absorb large quantities of potassium from the soil. In agriculture, this leads to a lack of available potassium in the soil - which is why the mineral is an important component in fertilisers. A team of German and Chinese researchers has now shown, for the first time, where and how plants detect potassium deficiency in their roots, and which signalling pathways coordinate the adaptation of root growth and potassium absorption to to uphold the plants potassium supply.

The background: The absorption and transportation of potassium at the level of individual cells have been relatively well characterised, and many of the molecular structures and mechanisms which play a role in these processes are known. Also, researchers demonstrated decades ago that plants adapt very specifically to potassium deficiency. One puzzle that still remains, however, is how plants detect the availability of potassium in the soil and which mechanisms are behind the adaptational reactions in the plant's organism. The new study sheds light on these questions. The results have been published in the journal Developmental Cell

Observations contradict the textbooks

The researchers examined thale cress plants (Arabidopsis thaliana) which were transformed with the newly developed potassium reporter protein GEPII. This reporter protein enables the microscopic detection of the concentration and distribution of potassium ions in cells and tissues. Even when there was no potassium deficiency, the research team made a very surprising discovery: the concentration of this nutrient in the cytoplasm of the cells increased with each cell layer within the root, from the outside to the inside.

"These observations were really surprising," says Prof. Jörg Kudla from the Institute of Plant Biology and Biotechnology at the University of Münster (Germany).

> **"They contradict the textbooks, which say that the nutrients are passed on evenly, from the outside to the inside, towards the root's vascular tissue - not only from cell to cell but also through the intercellular spaces."**

"Potassium-sensitive niche" reacts to potassium deficiency

The team of researchers subsequently examined how roots react to potassium deficiency. In doing so, they demonstrated for the first time that if plants are subjected to potassium deficiency, the concentration of potassium is reduced only within certain cells in the root tip. These "postmeristematic cells" directly above the viable stem cells in the root tip react extremely rapidly to potassium deficiency; the concentration of potassium inside the cell (in the cytoplasm) decreases within seconds. It had not previously been known that a certain group of cells located centrally inside the root tip reacts to a potassium deficiency in its surroundings. The researchers named this group of cells "potassium-sensitive niche".

"These observations, too, were very surprising," says Kudla. "If plants are deprived of potassium, only the cells in the potassium-sensitive niche show a reaction; the concentration of potassium in the other root cells remains unchanged. Previously it was assumed that naturally the cells in the outermost cell layer, the epidermis, would react first to a reduction in the concentration of potassium in the soil."

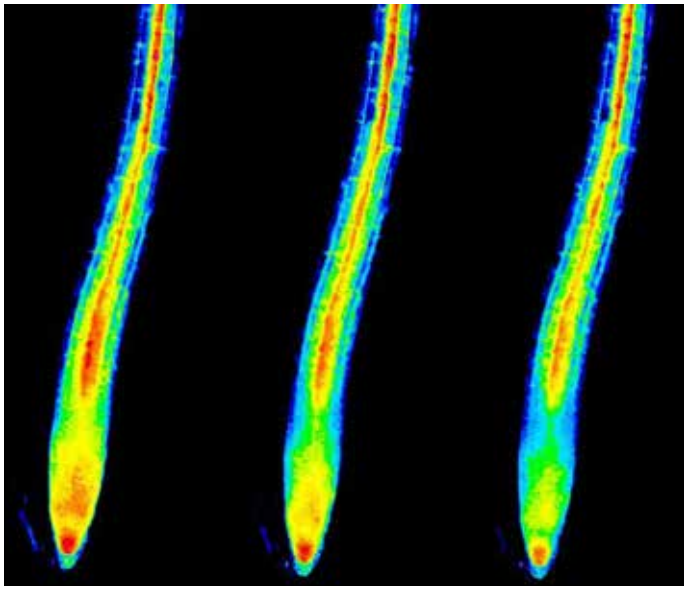
Visualising the path of potassium

Simultaneously with the decrease in the potassium concentration in the potassium-sensitive niche, calcium signals occur in these cells and spread out in the root. As a messenger substance, calcium controls many processes in living organisms - just as it does here: the calcium signals start off a complex molecular signalling cascade. This chain of signals, which the researchers were the first to define in detail, ultimately causes not only an increased formation of potassium transport proteins, but also brings about changes in tissue differentiation in the root. This facilitates a more efficient absorption of potassium ions and maintains its distribution in the plant. "For the first time," says Kudla, "using imaging methods, we have visualised the path of potassium in a living organism."

The results provide fundamental insights into where plants detect the availability of the essential nutrient potassium and how they adapt to it. Understanding these processes could in future help to breed better plants for agricultural purposes and deploy fertilisers in a more tailor-made way.

The methodology

To visualise the distribution of potassium in the plant's roots, the researchers used special microscopic methods (for example, Förster resonance energy transfer, FRET), in combination with sensor proteins for potassium, calcium and hydrogen peroxide. In order to examine the molecular mechanisms, the researchers produced and compared transgenic Arabidopsis plants which, due to different genetic mutations, showed symptoms of potassium deficiency. They used a variety of genetic, molecular-biological and biochemical methods to identify and characterise the proteins and mechanisms involved in the transmission of the potassium and calcium signals.



Potassium concentration in root cells (cytosol) immediately after the onset of potassium deficiency (time series, from left). Representation in false colours; red (highest concentration) > yellow > green > blue (lowest concentration).
CREDIT: WWU - AG Kudla

SCIENTISTS CREATED EDIBLE FOOD FILMS FOR FOOD PACKAGING

An international group of scientists from India and Russia has created edible food films for packaging fruits, vegetables, poultry, meat, and seafood. Films consist of natural ingredients, they are safe for health and the environment. In addition, films are water-soluble and dissolve by almost 90% in 24 hours. Description of the research and results of experiments are published in the Journal of Food Engineering.

"We have created three types of food films based on the well-known naturally occurring seaweed biopolymer sodium alginate," said Rammohan Aluru, senior researcher Organic synthesis laboratory at Ural Federal University and co-author of the paper. "Its molecules have film-forming properties. Sodium alginate is an auspicious carbohydrate macromolecule that has the potential film-forming properties upon hydrolysis and abundantly existed in cell walls as a mixture of various salts. The greatest advantage of sodium alginate is that it performs as liquid-gel in an aqueous medium."

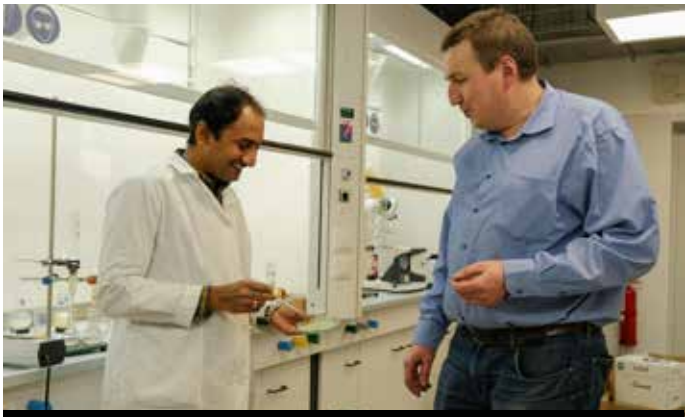
Alginate molecules were cross-linked with a natural antioxidant ferulic acid. It makes the film not only strong, but also homogeneous, more rigid, and prolongs the life of the products.

"Food stays fresh longer due to the antioxidant components that slow down the oxidation processes," said Grigory Zyryanov, professor of the Department of Organic and Biomolecular Chemistry at Ural Federal University.

"In addition, we can add to the films natural antiviral agents, that will also extend the shelf life of food. Garlic, turmeric, and ginger contain compounds that may prevent the spread of the viruses."

According to the authors, no special equipment for the production of films is required. On an industrial scale, it can be created by food products and films manufacturers.

"It can also be produced at a polymer production plant. The only condition is that it must meet the standards that apply to food production. And if an inexhaustible source of algae the ocean is nearby it will be quite simple to create such films," said Grigory Zyryanov.



Rammohan Aluru and Grigoriy Zyryanov ones on scientists group, who have developed edible food films based on seaweed (stripped off solution of ferulic acid and sodium alginate in a Petri dish).

SOILS OR PLANTS WILL ABSORB MORE CO2 AS CARBON LEVELS RISE - BUT NOT BOTH

Carbon dioxide in the atmosphere fuels plant growth. As carbon levels rise, it's appealing to think of supercharged plant growth and massive tree-planting campaigns drawing down the CO2 produced by fossil fuel burning, agriculture and other human activities.

New research published March 24 in Nature, however, suggests that when elevated carbon dioxide levels drive increased plant growth, it takes a surprisingly steep toll on another big carbon sink: the soil.

One likely explanation, the authors say, is that plants effectively mine the soil for nutrients they need to keep up with carbon-fueled growth. Extracting the extra nutrients requires revving up microbial activity, which then releases CO2 into the atmosphere that might otherwise remain locked in soil.

The findings contradict a widely accepted assumption that biomass and soil carbon will increase in tandem as more plant biomass falls to the ground and turns into organic matter. By analysing data from 108 previously published experiments dealing with soil carbon levels, plant growth and high concentrations of CO2 in the air, the authors were surprised to find the opposite.

"When plants increase biomass, usually there's a decrease in soil carbon storage," said lead author César Terrer, a fellow at Lawrence Livermore National Lab who worked on the research as a postdoctoral scholar at Stanford University.

Terrer and colleagues found soils only accumulated more carbon in experiments where plant growth remained fairly steady despite high levels of carbon in the atmosphere. "It proved much harder than expected to increase both plant growth and soil carbon," said senior study author Rob Jackson, a professor of Earth system science in Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth).

Widely used climate projections today don't account for this tradeoff, Jackson said. As a result, they likely overestimate the potential of land to draw down carbon dioxide from Earth's atmosphere.

Plants and soils together currently absorb an estimated 30 percent of the CO2 emitted by human activities each year. Predicting how the underground portion of this carbon sink will change in the coming decades is especially important because carbon absorbed by soil tends to stay there for a long time. "When a plant dies, some of the carbon that accumulated in its biomass may return to the atmosphere. In soils, carbon can be stored for centuries or millennia," Terrer explained.

The work builds on research Terrer, Jackson and colleagues published in 2019 estimating that a doubling of atmospheric CO2 from pre-industrial levels - as expected by the end of this century - will increase plant biomass by only about 12 percent. In other words, plants will likely play a far less significant role in drawing down carbon than previously predicted.

Now, by examining how carbon storage works in plants and soils together, the scientists have found that expectations for another piece of the climate puzzle also need to be revised. "Soils store more carbon worldwide than is contained in all plant biomass. They need much more attention as we project the fate of forests and grasslands to the changing atmosphere," said Jackson, who is also a senior fellow at the Stanford Woods Institute for the Environment.

The research suggests grasslands may absorb unexpectedly large amounts of carbon in the coming decades. Under a scenario where atmospheric CO2 doubles pre-industrial levels the researchers estimate carbon uptake in grassland soils will increase 8 percent, while carbon uptake by forest soils will remain roughly flat. That's in spite of CO2 enrichment giving a greater boost to biomass in forests (23 percent) than in grasslands (9 percent), partly because trees allocate belowground a relatively small portion of the carbon they absorb.

"From a biodiversity point of view, it would be a mistake to plant trees in natural grassland and savanna ecosystems," Terrer said. "Our results suggest these grassy ecosystems with very few trees are also important for storing carbon in soil."

PHYTOL MAY BE PROMISING FOR ECO-FRIENDLY AGROCHEMICALS TO CONTROL ROOT-KNOT NEMATODES

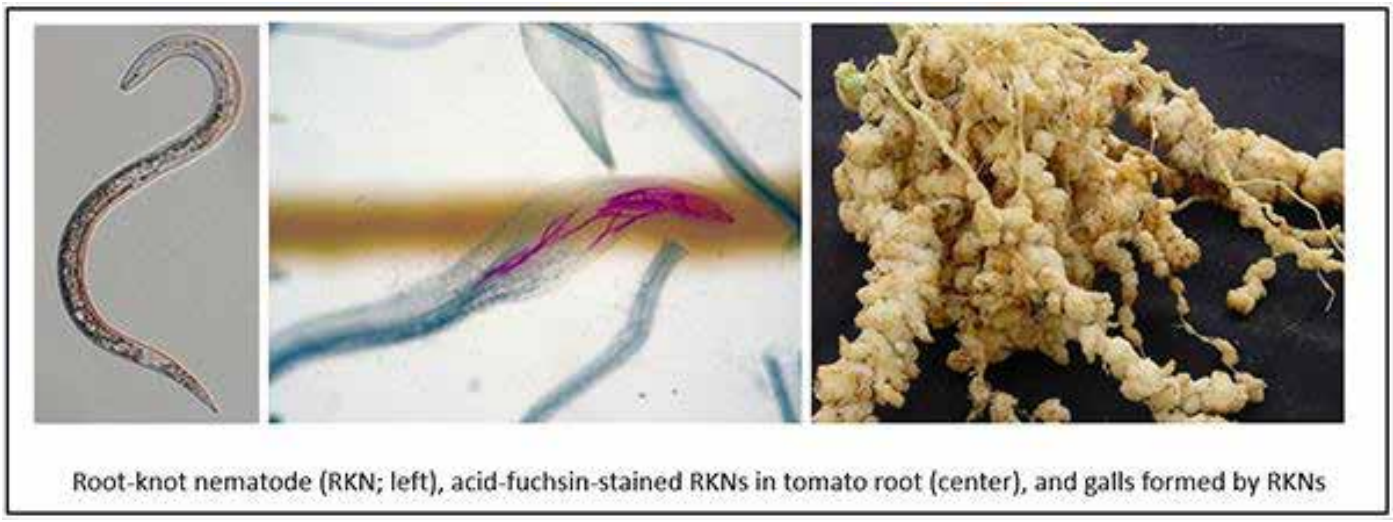
Root-knot nematodes (RKNs, Meloidogyne spp.) infect a broad range of plants, including several agriculturally important species such as cotton, soybean and corn, as well as various vegetables and ornamentals. These parasites cause roots to develop galls that result in severe plant damage and, ultimately, important crop losses. Growers currently use synthetic nematicides to manage RKNs; however, these compounds are detrimental to the microbial diversity of soil and harmful for the environment. Thus, it is necessary to develop alternative sustainable control methods.

"We have been seeking natural compounds that activate plant defence systems and do not have direct nematicidal activity using the combination of RKNs and their host plants," explained Shigemi Seo, researcher at the National Institute of Agrobiological Sciences of Japan.

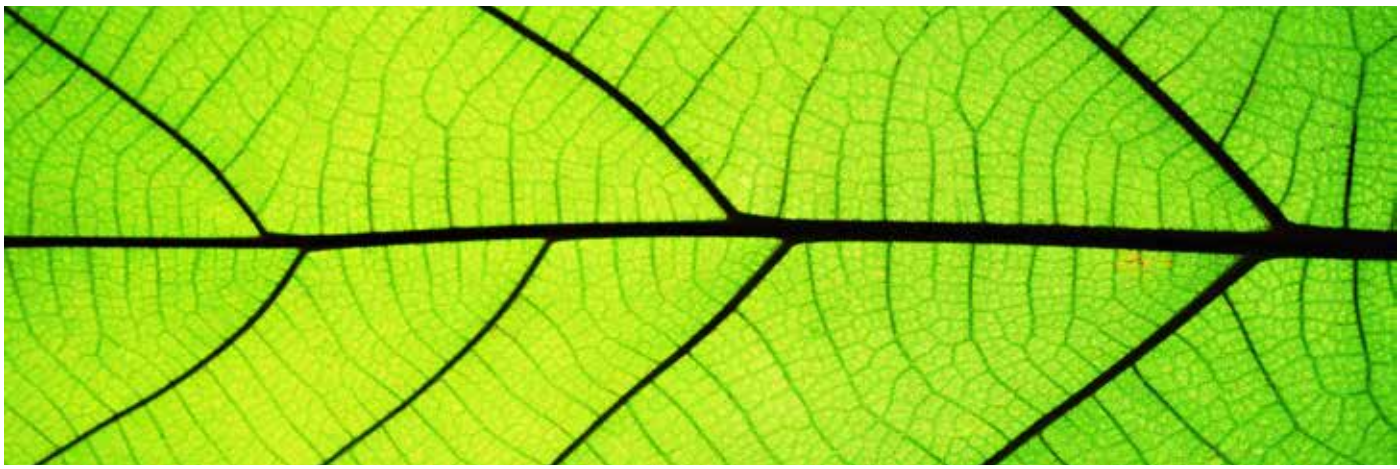
"We were most excited to discover that phytol, a chlorophyll constituent, has an inhibitory effect on the root invasion by a certain harmful plant nematode without killing it. We did not expect this molecule to be involved in RKN resistance."

"We noticed that plant leaves discoloured yellow or pale green when their roots were parasitised by RKNs and confirmed a decrease in chlorophyll content in such leaves. We hypothesised that chloroplast-related compounds would accumulate in RKN-parasitized roots and induce the host defence against RKNs. We analysed root metabolites and found accumulation of phytol, a constituent of chlorophyll. When phytol was applied to plant roots, RKN invasion of the roots was inhibited. This inhibition was not due to the direct nematicidal activity of phytol, since this compound did not kill RKNs," added Seo.

Even though phytol has been known for several years as a constituent of chlorophyll and is a ubiquitous compound present in almost all photosynthetic organisms, its role as a plant defence-signaling molecule remained unexplored. "Phytol may be a promising material for eco-friendly agrochemicals for the control of RKNs. We are currently investigating its effects on not only other plant parasitic nematodes but also other pathogenic microorganisms." For more information about this study, read "Phytol, a Constituent of Chlorophyll, Induces Root-Knot Nematode Resistance in Arabidopsis via the Ethylene Signaling Pathway" in the MPMI journal.



Root-knot nematode left; acid-fuchsin-stained RKNs in tomato root (center); gals formed by RKNs **CREDIT:** Taketo Fujimoto, Hiroshi Abe, Takayuki Mizukubo, and Shigemi Seo



BENEFICIAL BACTERIA HELP WHEAT STAND THE HEAT

Bacteria plucked from a desert plant could help crops survive heatwaves and protect the future of food.

Global warming has increased the number of severe heatwaves that wreak havoc on agriculture, reduce crop yields and threaten food supplies. However, not all plants perish in extreme heat. Some have natural heat tolerance, while others acquire heat tolerance after previous exposure to higher temperatures than normal, similar to how vaccines trigger the immune system with a tiny dose of virus.

But breeding heat tolerant crops is laborious and expensive, and slightly warming entire fields is even trickier.

There is growing interest in harnessing microbes to protect plants, and biologists have shown that root-dwelling bacteria can help their herbaceous hosts survive extreme conditions, such as drought, excessive salt or heat.

"Beneficial bacteria could become one of the quickest, cheapest and greenest ways to help achieve sustainable agriculture," says postdoc Kirti Shekhawat. "However, no long-term studies have proven they work in the real world, and we haven't yet uncovered what's happening on a molecular level," she adds.

To fill this knowledge gap, Shekhawat, along with a team led by Heribert Hirt, selected the beneficial bacteria SA187 that lives in the root of a robust desert shrub, Indigofera argentea. They coated wheat seeds with the bacteria and then planted them in the lab along with some untreated seeds. After six days, they heated the crops at 44 degrees Celsius for two hours. "Any longer would kill them all," says Shekhawat.

The untreated wheat suffered leaf damage and ceased to grow, while the treated wheat emerged unscathed and flourished, suggesting that the bacteria had triggered heat tolerance. "The bacteria enter the plant as soon as the seeds germinate, and they live happily in symbiosis for the plant's entire life," explains Shekhawat.

The researchers then grew their wheat for several years in natural fields in Dubai, where temperatures can reach 45 degrees Celsius. Here, wheat is usually grown only in winter, but the bacteria-bolstered crops consistently had yields between 20 and 50 percent higher than normal. "We were incredibly happy to see that a single bacterial species could protect crops like this," says Shekhawat.

The team then used the model plant Arabidopsis to screen all the plant genes expressed under heat stress, both with and without the bacteria. They found that the bacteria produce metabolites that are converted into the plant hormone ethylene, which primes the plant's heat-resistance genes for action. "Essentially, the bacteria teach the plant how to use its own defense system," says Shekhawat.

Thousands of other bacteria have the power to protect plants against diverse threats, from droughts to fungi, and the team is already testing some on other crops, including vegetables. "We have just scratched the surface of this hidden world of soil that we once dismissed as dead matter," says Hirt. "Beneficial bacteria could help transform an unsustainable agricultural system into a truly ecological one."

HOW GRASSLANDS RESPOND TO CLIMATE CHANGE

"Based on field experiments with increased carbon dioxide concentration, artificial warming, and modified water supply, scientists understand quite well how future climate change will affect grassland vegetation. Such knowledge is largely missing for effects that already occurred in the last century," says Hans Schnyder, Professor of Grassland at the TUM.

Based on the Park Grass Experiment at Rothamsted, researchers have now shown that future predicted effects of climate change on the nutrient status of grassland vegetation have already taken hold in the last century.

Plant intrinsic mechanisms respond to CO2 increase

Since 1856, research at Rothamsted has been testing the effects of different fertiliser applications on yield performance and botanical composition of hay meadows. Harvested material has been archived since the experiment began. This material is now available to researchers for studies of vegetation nutrient status, and the carbon and oxygen isotope composition of biomass.

"The increase in atmospheric CO2 concentration also affect the carbon, water, and nitrogen cycles in grasslands as well as other biomes," says Professor Schnyder. The mechanism that controls gas exchange with ambient air (the stomatal conductance of the plant canopy) is a key player in these cycles.

Plants control how far their stomata, small pores in the leaf epidermis, open to optimise the balance between carbon dioxide uptake (photosynthesis) and water loss (transpiration). With increased CO2 exposure, they reduce stomatal aperture to save water. This effect is particularly efficient in grasses. However, a reduction in transpiration leads to a reduced mass flow from the soil to the roots and leaves, which can result in reduced nitrogen uptake and feed back to weaken photosynthetic capacity.

Yield reduction and deterioration of the nitrogen nutrition status

Combining the new analyses of oxygen and carbon isotope composition, nitrogen and phosphorus in biomass, and yield and climate data, the research team, led by Professor Schnyder, analysed the physiological effects of the emission-related increase in CO2 concentration (about 30%) and associated past climate change.

They found that in particular the grass-rich communities that were heavily fertilised with nitrogen experienced a deterioration in their nitrogen nutrition status. Climate change also resulted in greatly reduced stomatal conductance (now detectable with the new research methods) and significantly reduced yields.

The core element of the researchers' observations is the hypersensitive CO2 response of stomata in grasses which they believe limits transpiration-driven nitrogen uptake.

Nitrogen fertilisation has no positive effects on grassland yield performance

"We also observed that fields that were heavily fertilised with nitrogen, and therefore rich in grass, largely lost their yield superiority over forbs- and legume-rich fields that were either less or completely unfertilised with nitrogen despite being otherwise equally supplied with nutrients over the course of the last century," says the first author of the study Juan Baca Cabrera, who is pursuing a doctorate at the TUM's chair of Grassland.

In the researchers' view, the results indicate that restraining nitrogen supply to grasslands in the future would enhance the yield contribution from forbs and legumes while at the same time would help limit nitrogen emissions to the environment. Professor Schnyder states, "Our findings are important for understanding the importance of grasses in earth systems and provide guidance for sustainable future grassland use."

FLOATING SOLAR FARMS COULD HELP REDUCE IMPACTS OF CLIMATE CHANGE ON LAKES AND RESERVOIRS

Floating solar farms could help to protect lakes and reservoirs from some of the harms of climate change, a new study suggests.

However, given the complex nature of water bodies and differing designs of solar technologies, there could also be detrimental ecosystem impacts of deploying floating solar arrays.

Conventional solar farms are controversial due to the amount of land they take up. This is leading to increasing interest in floating solar farms - making use of the additional space that bodies of water provide.

So far, there are three commercial-size floating solar arrays in the UK, and hundreds more across the world. The number of installations is likely to grow significantly in coming decades as demand rises for renewable energy sources with more countries committing to net zero carbon targets.

However, little is known about the impacts - both positive and negative - these floating solar farms are having on the lakes and reservoirs they are installed on - until now.

Scientists from Lancaster University and the University of Stirling have completed the first detailed modelling of the environmental effects of floating solar installations on bodies of water.

"As demand for land increases, water bodies are increasingly being targeted for renewable energy. Deployment of solar on water increases electricity production, but it is critical to know if there will be any positive or negative environmental consequences," said Mr Giles Exley, PhD researcher and lead author from Lancaster University.

"Given the relative immaturity of floating solar farms, it is important to further scientific evidence of the impacts. Our results provide initial insight of the key effects that will help inform water body manager and policy maker decisions."

The research team undertook computer modelling using the MyLake simulation programme and data collected by the UK's Centre for Ecology and Hydrology from England's largest lake, Windermere. Although the researchers believe it is unlikely floating solar farms will be deployed on Windermere, it presents a rich data-set as it is one of the most comprehensively studied lakes in the world.

Their results show that floating solar arrays can cool water temperatures by shading the water from the sun. At scale, this could help to mitigate against harmful effects caused by global warming, such as blooms of toxic blue green algae, and increased water evaporation, which could threaten water supply in some regions.

The scientists found that floating solar installations also reduce the duration of 'stratification' - this is where the sun heats the water, forming distinct layers of water at different temperatures. This tends to happen more in the warmer summer months and can result in the bottom layer of water becoming deoxygenated, which deteriorates water quality - an obvious issue for supplies of drinking water. However, the picture is complex and there are also conditions under which stratification, and therefore detrimental water quality impacts, could increase if floating solar farms are deployed.

Mr Exley said: "The effects of floating solar on the temperature of the water body and stratification, both of which are major drivers of biological and chemical processes, could be comparable in magnitude to the changes lakes will experience with climate change. Floating solar could help to mitigate against the negative effects global warming will have on these bodies of water."

"However, there are also real risks of detrimental impacts, such as deoxygenation causing undesirable increases in nutrient concentrations and killing fish. We need to do more research to understand the likelihood of both positive and negative impacts."

The effects on water temperature increased the larger the solar installation, with small arrays of less than ten per cent of the lake surface generally having minimal impacts. However, this model concentrated on one lake. Further studies will be needed to determine the optimum size array, and design, and their effects for individual lakes and reservoirs - all of which have unique characteristics. Different designs of solar installations also have different shading and sheltering effects for the sun and wind.

Arrays covering more than 90 per cent of a lake could increase the chances of the lake freezing over in winter, the study found - though these effects would also be specific to the body of water and design of the installation and require further studying.

Field studies and further modelling work to build on these initial findings is ongoing.

RESEARCHERS IMPROVE PLANT PRIME EDITING EFFICIENCY WITH OPTIMISED PEGRNA DESIGNS

Precision genome editing enables the precise modification of DNA in living cells, thus enabling a breadth of opportunities for plant breeding. Prime editors, developed by Prof. David R. Liu and his colleagues, permit the installation of desired edits in a programmable target site. They are comprised of an engineered Cas9 nickase (H840A)-reverse transcriptase (RT) fusion protein and a prime editing guide RNA (pegRNA).

Prime editors were previously developed and optimised as an extremely versatile editing strategy for generating programmable point mutations, insertions and deletions in rice and wheat by Prof. GAO Caixia of the Institute of Genetics and Developmental Biology (IGDB) of the Chinese Academy of Sciences along with her research team and collaborators.

They found that the editing efficiency of the plant prime editor was strongly affected by the PBS and RT template sequence, suggesting the need for optimised pegRNA designs to yield higher product conversions.

To determine principles for efficient prime editing, Prof. GAO and Prof. LI Jiayang, also of IGDB, along with their research teams, reported optimised pegRNA design strategies that maximise plant prime editing efficiency.

Since the hybridisation of the primer binding site (PBS) with the non-target strand ssDNA is the initial step in reverse transcription, the researchers hypothesised that the melting temperature (Tm) of the PBS sequence (referred to hereafter as PBS Tm) is an important parameter for prime editors. By analysing prime editing efficiencies at 18 endogenous target sites in rice protoplasts, they found that PBS Tm strongly affects editing efficiency, with maximal prime editing occurring when PBS Tm is 30 °C in rice.

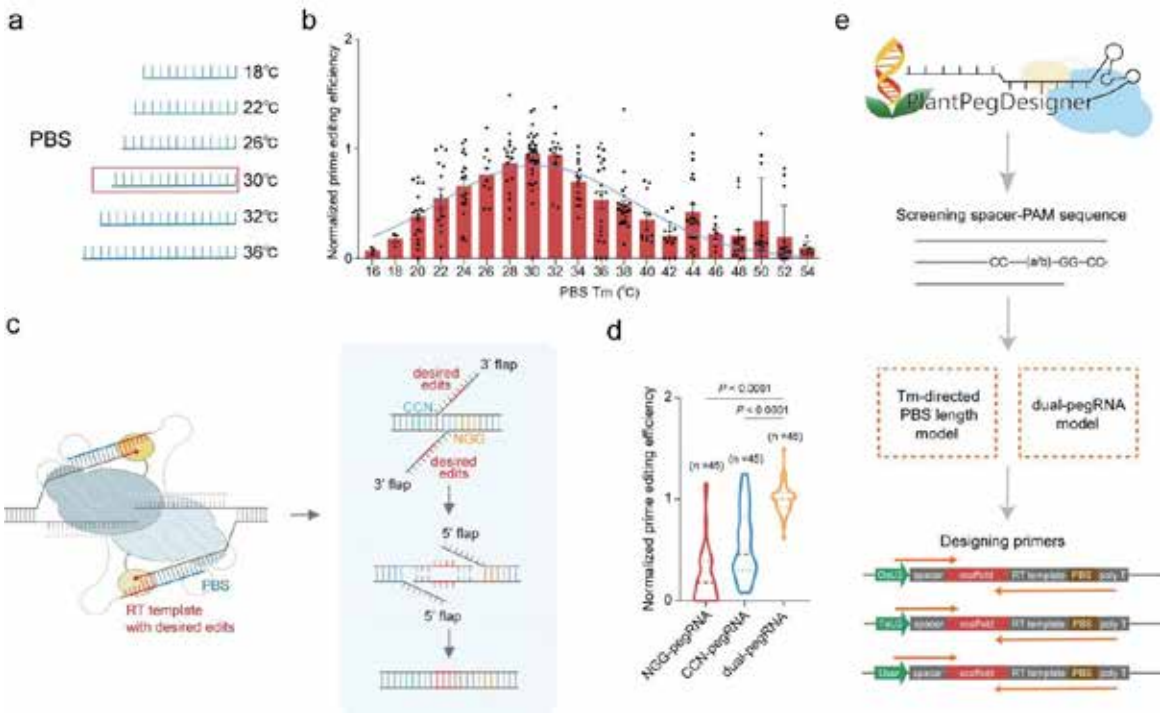
In addition to identifying optimal pegRNA designs, they also introduced advances to prime editing through the use of dual pegRNAs. This strategy relies on two pegRNAs generating respective ssDNA flaps that base pair with each other in trans while encoding the same edit on both strands of the newly synthesised DNA.

This new editing approach resulted in 3.0-fold improvements in average in prime editing efficiency compared to using individual pegRNAs alone. Furthermore, the scientists generated prime editors comprised of SpG (an engineered Cas9 with expanded PAM targeting range) to expand the targeting scope of this dual-pegRNA editing strategy. Together, optimising PBS Tm and using a dual-pegRNA strategy boosted prime editing efficiency up to 17.4-fold in rice.

Based on these two advancements, the team developed a user-friendly web application, PlantPegDesigner, to help other researchers design prime editing tools best suited for their applications.

PlantPegDesigner offers users flexibility and control of various parameters based on their individual needs. This tool recommends spacer-PAM sequences, PBS sequences, RT template sequences and also PCR cloning primers for vector construction. Compared to other web applications, PlantPegDesigner-recommended dual pegRNAs resulted in up to a 46-fold improvement in editing activity in rice.

In summary, this work simplified the design of pegRNAs, thus providing a reliable solution for efficient prime editing in plants. The flexibility of the optimised plant prime editing system will advance both plant breeding and functional genomics research.



(a). Diagram of optimizing the PBS Tm; **(b).** Prime editing frequencies at different PBS Tm in rice; **(c).** Diagram of prime editing using the dual-pegRNA strategy; **(d)**. Comparison of the dual-pegRNA strategy with either pegRNA alone; **(e).** Schematic representation of using PlantPegDesigner to design pegRNAs. **CREDIT:** IGDB

'KEEP OFF THE GRASS': THE BIOFUEL THAT COULD HELP US ACHIEVE NET ZERO

The Miscanthus genus of grasses, commonly used to add movement and texture to gardens, could quickly become the first choice for biofuel production. A new study shows these grasses can be grown in lower agricultural grade conditions - such as marginal land - due to their remarkable resilience and photosynthetic capacity at low temperatures.

Miscanthus is a promising biofuel thanks to its high biomass yield and low input requirements, which means it can adapt to a wide range of climate zones and land types. It is seen as a viable commercial option for farmers but yields can come under threat from insufficient or excessive water supply, such as increasing winter floods or summer heat waves.

With very little known about its productivity in flooded and moisture-saturated soil conditions, researchers at the Earlham Institute in Norwich wanted to understand the differences in water-stress tolerance among Miscanthus species to guide genomics-assisted crop breeding.

The research team - along with collaborators at TEAGASC, The Agriculture and Food Development Authority in the Republic of Ireland, and the Institute of Biological, Environmental and Rural Sciences in Wales - analysed various Miscanthus genotypes to identify traits that provided insight into gene adaptation and regulation during water stress.

They found specific genes that play key roles in response to water stress across different Miscanthus species, and saw consistencies with functional biological processes that are critical during the survival of drought stress in other organisms.

Dr Jose De Vega, author of the study and Group Leader at the Earlham Institute, said: "Miscanthus is a commercial crop due to its high biomass productivity, resilience, and ability to continue photosynthesis during the winter months. These qualities make it a particularly good candidate for growth on marginal land in the UK, where yields might otherwise be limited by scorching summers and wet winters."

Previously, a decade-long trial in Europe showed that Miscanthus produced up to 40 tonnes of dry matter per hectare each year. This was reached after just two years of establishment, proving its biofuel capacity was more efficient in ethanol production per hectare than switchgrass and corn.

Miscanthus species have been used as forage species in Japan, Korea and China for thousands of years and, due to its high biomass yield and high ligno-cellulose (plant dry matter) content, they are commercially used as feedstock for bioenergy production.

Ligno-cellulose biomass is the most abundantly available raw material on Earth for the production of biofuels, mainly producing bio-ethanol. Miscanthus's high biomass ability makes the grass a valuable commodity for farmers on marginal land but the crop's responses to water-stress vary depending on the Miscanthus species' origin.

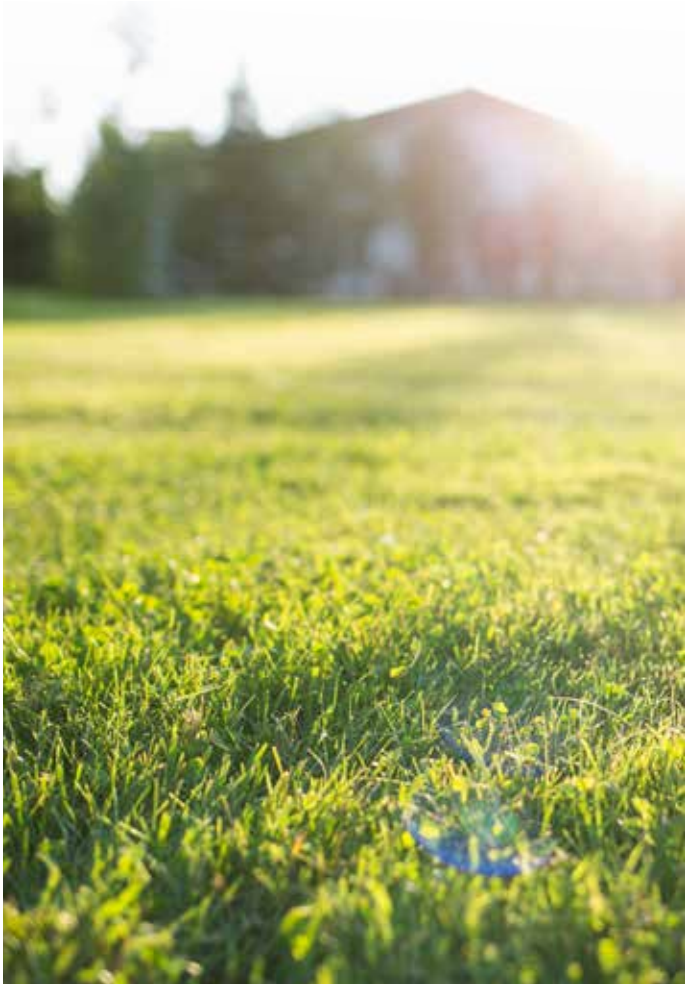
The scientists compared the physiological and molecular responses among Miscanthus species in both water-flooded and drought conditions. The induced physiological conditions were used for an in-depth analysis of the molecular basis of water stress in Miscanthus species.

A significant biomass loss was observed under drought conditions in all of the four Miscanthus species. In flooded conditions, biomass yield was as good as or better than controlled conditions in all species. The low number of differentially expressed genes, and higher biomass yield in flooded conditions, supported the use of Miscanthus in flood-prone marginal land.

"The global challenge of feeding the ever-increasing world population is exacerbated when food crops are being used as feedstock for green energy production," said Dr De Vega.

"Successful plant breeding for ethanol and chemical production requires the ability to grow on marginal lands alongside prioritising the attributes; non-food related, perennial, high biomass yield, low chemical and mechanical input, enhanced water-use efficiency and high carbon storage capacity. Miscanthus fulfils these for enhanced breeding - saving money and space for farmers, and lending a hand to our over polluted environment by emitting CO2.

"The research team is in the early selection process of high biomass genotypes from large Miscanthus populations that are better adapted to the UK conditions and require low inputs. The use of genomic approaches is allowing us to better understand the traits that make some Miscanthus species a commercially sustainable alternative for marginal lands and applying this to agri-practices."



GENOME SEQUENCED FOR PESKY PUMPKIN PATHOGEN

URBANA, Ill. - Pumpkin growers dread the tiny tan scabs that form on their fruit, each lesion a telltale sign of bacterial spot disease. The specks don't just mar the fruit's flesh, they provide entry points for rot-inducing fungus and other pathogens that can destroy pumpkins and other cucurbits from the inside out. Either way, farmers pay the price, with marketable yields reduced by as much as 90%.

Despite the disease's severity, scientists don't know much about the genetics of the pathogen that causes it; nearly all the molecular information required for accurate diagnostic testing and targeted treatments is lacking for the disease.

In a new study, University of Illinois scientists, with the help of two undergraduate students, have assembled the first complete genome for the bacteria that causes the disease, Xanthomonas cucurbitae, and identified genes that are activated during infection.

"Assembling a complete circular genome means we now have the resources to better understand what's happening in the field. We can use this information to look at how the pathogen is spreading, whether there are differences in host specificity among sub-populations or strains, or how likely it is to develop resistance to chemical controls," says Sarah Hind, assistant professor in the Department of Crop Sciences at Illinois and senior author on the Phytopathology study.

After sequencing the genome, Hind's group compared it to genomes from 12 other Xanthomonas species that cause diseases in a variety of crop plants like tomato, rice, citrus, and wheat. Surprisingly, given its penchant for creating havoc in the field, Xanthomonas cucurbitae had the smallest genome and had fewer genes known to be important for other Xanthomonas species to cause disease.

"As this pathogen lacks many of the known virulence (i.e., disease-causing) genes, we don't know exactly which genes are needed by the pathogen to infect cucurbit plants," Hind says.

"It could be something we've never seen before, such as a new gene or a mechanism that evolved in this species that isn't seen in the rest of the family. That could be very exciting."

University of Illinois researchers, including Rikky Rai (pictured) and Sarah Hind, have sequenced the genome for the bacterium that causes bacterial spot disease in pumpkin, an economically devastating disease. **CREDIT:** Montgomery Flack

To get closer to an answer, the research team grew the bacteria in liquid media that mimicked its host environment and identified more than 400 genes whose expression was altered when the pathogen interacted with its "host." In particular, they observed increased expression of genes for enzymes related to the breakdown of plant tissues, which are key for further development of the disease.

If Hind's team can learn more about these factors and how cucurbits respond to them, there may be a way to prevent the bacteria from penetrating pumpkin fruits in the first place. "That would really save the farmers," she says. "They don't care as much when it gets on the leaves, but if it infects the fruit, they're in trouble."

Hind adds, "This project wouldn't have been possible without the contributions of some really talented undergraduate students. We love having students participate in our research. They bring a sense of enthusiasm and eagerness - as well as really creative ideas - to the lab that would be hard to generate otherwise."

Although both students graduated, see new Crop Sciences students contributing to Hind's other pumpkin projects in this video. High school and transfer students can learn more about Crop Sciences coursework online.

A GENETIC SOLUTION TO ENSURE SORGHUM STANDS FIRM

After decades of study, University of Queensland researchers have identified a genetic solution to the problem of sorghum lodging and falling down, which affects 10 per cent of sorghum crops each year.

Professor David Jordan from UQ's Queensland Alliance for Agriculture and Food Innovation (QAAFI) said lodging was when the stems of plants carrying high grain yields were weakened by loss of water.

"Losing a bumper grain crop because plants fall over is heartbreaking for growers and undermines efforts to increase production to improve food security," Professor Jordan said.

Working with the Department of Agriculture and Fisheries at the Hermitage Research Facility in Warwick, Professor Jordan found that lodging occurs whenever water scarcity halted photosynthesis.

"This forces the plants to rely on carbohydrates stored in the stems," he said.

"The metabolic shift ultimately weakens the stems, culminating in their death, while pathogens can invade and further weaken stems, causing them to break."

Doctoral student Xuemin Wang analysed data from 14 seasons and found that the most severe lodging – greater than 20 per cent – occurred in 2005, 2006 and 2017.

He found that the differences in air pressure recorded on the Southern Oscillation Index explained 29 per cent of the season variation in lodging frequency.

"Our data also found that despite substantial breeding efforts and turnover of commercial cultivars, the level of resistance to lodging does not appear to have improved," Professor Jordan said.

The research team, which also includes Dr Emma Mace who works for QAAFI and the Department of Agriculture and Fisheries and Professor Graeme Hammer, found that traits used to drive up yields also introduced a susceptibility to lodging.

An example is plant height, which is essential to achieving higher yields but also raises the risk of lodging-inducing stem failure.

"The higher the yield potential of a sorghum hybrid, the more likely it is to suffer from lodging, creating a challenge for breeders trying to improve both traits," Professor Jordan said.

He said to meet this challenge, scientists undertook one of the world's largest genome-wide association studies in sorghum.

"This study looked at 2308 unique hybrids grown in 17 Australian sorghum trials over three years," he said.

"A genome-wide view of the genetics is important as it means we can search the network of lodging-associated genes for those pathways we can target for improvement without sacrificing yield potential."

Professor Jordan said the team found one way to increase stem strength would be to alter the composition of the molecules used by the plant to assemble the supportive cell wall.

Bolstering disease resistance at the same time would offer additional protection.

The research team is now poised to translate these insights into targeted breeding strategies to directly benefit the Australian sorghum industry.

Previously, Queensland sorghum researchers introduced greater drought resistance into Australian cultivars by transferring 'stay-green genes' from sorghum sourced from Ethiopia.

Soghum lodging - Biloela

Stay-green genes are now recognised to have introduced a level of resistance to lodging by delaying photosynthesis shutdown and stem death in response to water scarcity.

"We are at the point where we have come as far as we can with the stay-green mechanism for reducing the incidence of lodging," Professor Jordan said.

"By generating the new genetic map, we can now identify new leads for breeding greater lodging resistance into high-yielding sorghum hybrids."

The sorghum core pre-breeding project was funded by the Department of Agriculture and Fisheries (DAF) Queensland, Grains Research and Development Corporation (GRDC) and UQ.

Xuemin Wang is financially supported by an Australian Government Research Training Program Scholarship and a Centennial Scholarship from UQ.

FINDING NEW LIFE FOR WINE-GRAPE RESIDUE

California produces nearly 4 million tons of world-class wine each year, but with that comes thousands of tons of residue like grape skins, seeds, stems and pulp. What if scientists could harness that viticultural waste to help promote human health?

Maybe they can, according to new research from food scientists at the University of California, Davis. In a study published in the journal LWT -- Food Science and Technology, the team discovered a wealth of potentially health-enhancing compounds and sugar molecules called oligosaccharides within chardonnay wine-grape pomace.

Oligosaccharides are found in many plant and animal tissues, including human breast milk. Recent advances have revealed oligosaccharides' vast potential to support intestinal health.

"We were surprised by the diversity of the oligosaccharides in the chardonnay wine grapes, including the presence of structural elements found in mother's milk," said Amanda Sinrod, lead author and a master's candidate working with Professor Daniela Barile.

The UC Davis team analysed the molecular composition of chardonnay residue provided by Jackson Family Wines and Sonomaceuticals, a company founded by two food industry businesswomen to develop new uses for viticulture waste. Wine-grape pomace, or marc, comprises about 30 percent of the original wine-grape material, and much of it is left to decompose in the sun.

Potential source for food or supplements

"It's all about sustainable wine production and finding a second life for wine grapes," Barile explained. "Up to this point, chardonnay marc has been regarded as a byproduct of winemaking with little or no value. Early results are encouraging that marc could be a valuable source for oligosaccharides and other compounds that support health and nutrition."

UC Davis researchers were among the first to decode the magic of oligosaccharides in mother's milk. The sugar molecules don't nourish the baby directly. Instead, they feed a strain of bacteria in the infant's intestines that helps build immunity against illness and disease. That discovery is helping scientists develop methods and products to improve human health.

Barile's lab innovates technologies for recovering health-enhancing compounds from various agricultural and industrial waste streams, such as whey, legumes and chickpeas. Her team previously discovered oligosaccharides in both red and white wine residue and is pleased with preliminary findings from the chardonnay analysis.

"There is more research to be done, but early results are promising that chardonnay marc can become a source for developing supplements and other food products to support health," Barile said.

Oligosaccharides appeared to be especially abundant in the wine-grape skins. In earlier research, scientists detected oligosaccharides in the finished wine product, but not in large concentrations. Researchers didn't include bottled wine in this study.

The chardonnay marc samples were also rich in flavonoids, healthy compounds found in many fruits and vegetables. Researchers are exploring whether the oligosaccharides work independently or synergistically with these bioactive compounds to support intestinal health. The team is studying how growing conditions, vintages and processing might affect the health potential of viticulture waste.

"We observed significant differences in the relative abundance and type of oligosaccharides in different parts of the marc, so further research is needed to maximise their potential in food product design," Sinrod said.

The UC Davis team included Cooperative Extension Specialist Selina Wang and Xuequi Li with the Olive Centre, and Mrittika Bhattacharya and Bruna Paviani with the Department of Food Science and Technology.

PLANT FLOWERING IN LOW-NITROGEN SOILS: A MECHANISM REVEALED

Scientists from Japan, Europe and the USA have described a pathway leading to the accelerated flowering of plants in low-nitrogen soils. These findings could eventually lead to increases in agricultural production.

Nitrogen is one of the three macronutrients required by plants for growth and development, along with phosphorus and potassium. Nitrogen-rich condition induces plant growth, particularly the growth of stems and leaves, while delaying flowering. On the other hand, in some plants, low-nitrogen conditions lead to a change from growth mode to reproductive mode, therefore accelerating flowering. However, the molecular mechanisms that regulate flowering under these conditions are not known.

A team of scientists led by Associate Professor Takeo Sato of Hokkaido University's Graduate School of Life Science has revealed the molecular mechanism responsible for the acceleration of flowering in Arabidopsis under low nitrogen conditions. Their findings were published in the journal Proceedings of the National Academy of Sciences (PNAS).

Arabidopsis, a cruciferous plant, is well known as a model plant in biology and has an extensive database of its protein expression. In the current study, the team first identified a set of proteins involved in flowering that became active as a result of changes in nitrogen level. One of these was the gene regulation factor FLOWERING BHLH 4 (FBH4). Through experiments using FBH4 deficient plants, this protein was found to be responsible for accelerated flowering under low-nitrogen conditions.

Further investigation suggested that FBH4 is extensively phosphorylated by another protein called SnRK1. Low-nitrogen conditions suppress SnRK1 activity, which in turn results in the dephosphorylation of FBH4. The dephosphorylated FBH4 moves to the nucleus to activate genes responsible for flowering. Dephosphorylated FBH4 is also responsible for controlling the expression of other genes vital for plant survival under low nitrogen conditions, particularly those related to nitrogen recycling and remobilisation.

The scientists concluded that, in response to inadequate nitrogen, Arabidopsis plants appear to precisely control gene expression related to developmental and metabolic processes required for flowering through FBH4.

"The FBH family of genes is present in major crop plants," says Takeo Sato. "Crop plants exhibit early flowering under low-nitrogen conditions; if we can control FBH activities in these crop plants, it might be an effective way to sustainably increase agricultural production."

Journal Reference:

Miho Sanagi, Shoki Aoyama, Akio Kubo, Yu Lu, Yasutake Sato, Shogo Ito, Mitsutomo Abe, Nobutaka Mitsuda, Masaru Ohme-Takagi, Takatoshi Kiba, Hirofumi Nakagami, Filip Rolland, Junji Yamaguchi, Takato Imaizumi, Takeo Sato. Low nitrogen conditions accelerate flowering by modulating the phosphorylation state of FLOWERING BHLH 4 in Arabidopsis. Proceedings of the National Academy of Sciences, 2021; 118 (19): e2022942118 DOI: 10.1073/pnas.2022942118

RUBISCO PROTON PRODUCTION CAN ENHANCE CO2 ACQUISITION

Rubisco is arguably the most abundant -- and most important -- protein on Earth. This enzyme drives photosynthesis, the process that plants use to convert sunlight into energy to fuel crop growth and yield. Rubisco's role is to capture and fix carbon dioxide (CO2) into sugar that fuels the plant's activities. However, as much as Rubisco benefits plant growth, it also can operate at a notoriously slow pace that creates a hindrance to photosynthetic efficiency.

About 20 percent of the time Rubisco fixes oxygen (O2) molecules instead of CO2, costing the plant energy that could have been utilised to create yield. This time- and energy-consuming process is called photorespiration, where the plant sends its enzymes through three different compartments within the plant cell.

"However, many photosynthetic organisms have evolved mechanisms to overcome some of Rubisco's limitations," said Ben Long who led this recent study published in PNAS for a research project called Realising Increased Photosynthetic Efficiency (RIPE). RIPE, which is led by Illinois in partnership with the Australian National University (ANU), is engineering crops to be more productive by improving photosynthesis. RIPE is supported by the Bill & Melinda Gates Foundation, Foundation for Food & Agriculture Research, and U.K. Foreign, Commonwealth & Development Office.

"Among these organisms are microalgae and cyanobacteria from aquatic environments, which have efficiently functioning Rubisco enzymes sitting inside liquid protein droplets and protein compartments called pyrenoids and carboxysomes," said lead researcher Long from the ANU Research School of Biology.

How these protein compartments assist in the Rubisco function is not entirely known. The team from ANU aimed to find the answer by using a mathematical model that focused on the chemical reaction Rubisco carries out. As it collects CO2 from the atmosphere, Rubisco also releases positively charged protons.

"Inside Rubisco compartments, these protons can speed up Rubisco by increasing the amount of CO2 available. The protons do this by helping the conversion of bicarbonate into CO2," said Long.

"Bicarbonate is the major source of CO2 in aquatic environments and photosynthetic organisms that use bicarbonate can tell us a lot about how to improve crop plants."

The mathematical model gives the ANU team a better idea as to why these special Rubisco compartments might improve the enzyme's function and it also gives them more insight into how they may have evolved. One hypothesis from the study suggests that periods of low CO2 in the earth's ancient atmosphere may have been the trigger for the cyanobacteria and microalgae to evolve these specialised compartments, while they might also be beneficial for organisms that grow in dim light environments.

ANU members of the Realising Increased Photosynthetic Efficiency (RIPE) project are trying to build these specialised Rubisco compartments in crop plants to assist in increasing yield.

"The outcomes of this study," explained Long, "provide an insight into the correct function of specialised Rubisco compartments and give us a better understanding of how we expect them to perform in plants."

Journal Reference:

Benedict M. Long, Britta Förster, Sacha B. Pulsford, G. Dean Price, Murray R. Badger. Rubisco proton production can drive the elevation of CO2 within condensates and carboxysomes. Proceedings of the National Academy of Sciences, 2021; 118 (18): e2014406118 DOI: 10.1073/pnas.2014406118

NEW ERA FOR OAT BREEDING: SIGNIFICANT INVESTMENT OVER THE NEXT FIVE YEARS TO ACCELERATE THE NATIONAL OAT BREEDING PROGRAM

The National Oat Breeding Program, backed by joint $5.4 million investment from AgriFutures Australia and the Grains Research and Development Corporation (GRDC) over five years, will be propelled into a new era under the leadership of commercial breeding company, InterGrain.

The $11.5 million* commercial breeding Program will provide new varieties for milling and hay oats, side-by-side, with a broad genetic base equipped to respond to the changing needs of Australian growers and exporters.

This Program is the only one of its type in the world and builds on research in hay and milling oat breeding by the South Australian Research and Development Institute (SARDI), a division of the Department of Primary Industries and Regions.

AgriFutures Australia Managing Director John Harvey acknowledged SARDI's leadership and importantly the commitment, and achievements of the breeding and technical staff.

"Firstly, I would like to acknowledge SARDI's research in oat breeding for more than 25 years, and particularly for its leadership of the National Program since 2003. Under SARDI's leadership, the Program has grown and continued to deliver high-quality grade hay and milling oat varieties for growers."

"AgriFutures looks forward to working with the GRDC and InterGrain, building on the foundation of SARDI's research and continuing to grow and maintain Australia's competitive advantage into the future."

GRDC Managing Director, Anthony Williams, said the outcome was a good example of how growers, through their Research Development Corporations, would be rewarded for upfront risk and investment.

"As significant cereal breeding expertise and capacity lies in the private sector, it's fantastic that the oats industry has developed to the point where commercial breeding investment has been attracted," said Mr Williams. "This is how commercialisation should work between RDCs and industry. The future looks very bright for oats in the growing 'super food' market."

Following a competitive tender process, InterGrain was selected to lead the Program as it transitions to a full commercial model by 2025. As one of the leaders in cereal breeding in Australia, InterGrain has extensive experience in transferring public breeding programs into the commercial sector and developing them into commercially focused breeding programs. They have identified priority activities in the short, medium and longer-term, to build a best practice oat breeding program and deliver benefits to hay and milling oat growers.

Short term

- Increasing population sizes and selection intensity
- Reduced time for variety development cycle (using speed breeding and summer nurseries)
- Improved seed delivery pipeline

Medium term

- Develop and apply genomic selection methods
- High throughput phenotyping of hay yield and quality

Longer term

- Widen the oat gene pool

Strong engagement with the grain and hay value chains has been, and will continue to be, a key strength of the program as it enters a new era. This is critical to ensure the retention of markets and growth opportunities for Australian milling and hay oats globally and in the domestic marketplace.

South Australian Minister for Primary Industries and Regional Development David Basham said, "Investing in grains research to boost productivity and farm profits is important to the Marshall Liberal Government."

"Research and development is a key component of the South Australian Grain Industry Blueprint, which aims to boost the sector to $6 billion by 2030."

"The South Australian Research and Development Institute is a proven leader in oat breeding with the development and release of 17 oat varieties, including eight hay varieties, over the past 20 years."

"These new oat varieties represent more than 80 per cent of the export hay produced, and nine milling varieties representing over 90 percent of milling oats. This includes the recent releases of Bilby and Koorabup," said Minister Basham.

InterGrain's strengths lie in variety breeding and market development, both in the domestic and international marketplace. InterGrain have strong research linkages across Australia and 40 research sites spread across the country, with over 200,000 field plots annually.

InterGrain Chief Executive Officer Tresslyn Walmsley said, "We are excited to take the baton and lead the National Oat Breeding Program. We will work closely with SARDI over the coming 12-18 months as we transition the program to a commercial model and build on SARDI's foundation research."

"InterGrain brings new technologies to the National Oat Breeding Program, such as technology to enable genomic oat breeding at a very low cost. InterGrain has developed a genomics platform with high SNP call rates and imputation for its barley and wheat program and will look to create a similar genomics tools to create a game changing asset for oat breeding."

"We are committed to continuing to work with industry to ensure national breeding targets are prioritised, on-farm productivity is increased, and market share, domestically and globally, continues to grow," said Ms Walmsley.

The National Oat Breeding Program will be led by InterGrain, through funding from AgriFutures Australia and the Grains Research and Development Corporation, and supported by the Government of South Australia and the Western Australian Government.

*The $11.5 million investment includes a joint contribution of $5.4 million from AgriFutures Australia and the Grains Research and Development Corporation as well as $5.4 million from InterGrain and $750,000 from the Western Australian Agriculture Authority.

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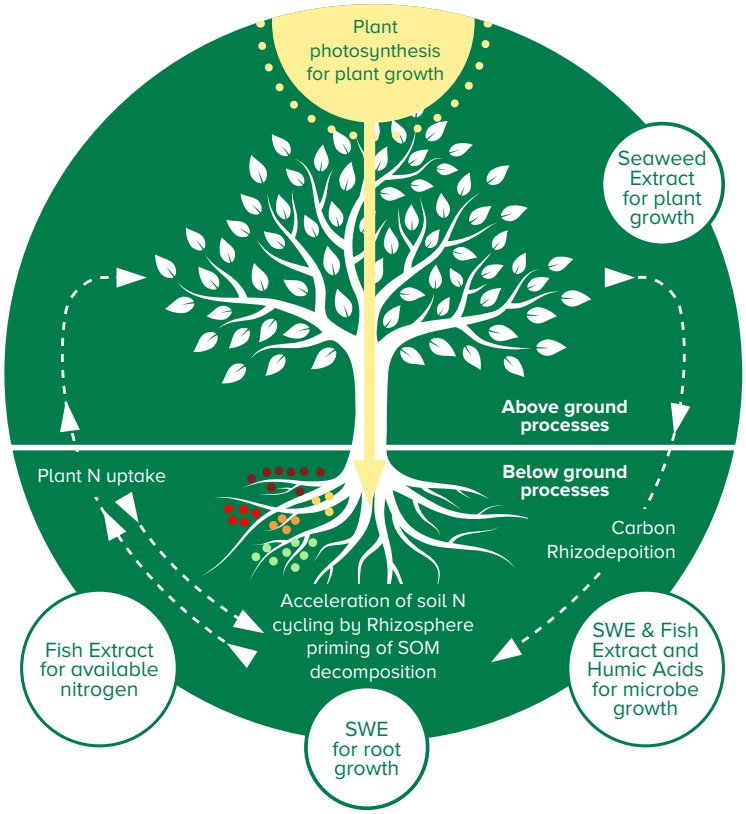

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