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THE AUSTRALIAN AGRONOMIST MAGAZINE

Plants control microbiome diversity inside leaves to promote health

Engineers develop precision injection system for plants

Universally positive effect of cover crops on soil microbiom

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PO BOX 812 Strathfieldsaye VIC Australia 3551 **P:** 03 5441 8166 **E:** info@theaustralianagronomist.com
W: www.theaustralianagronomist.com

Design & Advertising
Emma Hampton
Email: info@theaustralianagronomist.com
Phone: 03 5441 8166

Publisher
Paul Banks
Email: paul@theaustralianagronomist.com
Phone: 03 5441 8166

PLANTS CONTROL MICROBIOME DIVERSITY INSIDE LEAVES TO PROMOTE HEALTH

IN A RECENT STUDY, PUBLISHED IN THE JOURNAL NATURE, MICHIGAN STATE UNIVERSITY SCIENTISTS SHOW HOW PLANT GENES SELECT WHICH MICROBES GET TO LIVE INSIDE THEIR LEAVES IN ORDER TO STAY HEALTHY.

This is the first study to show a causal relationship between plant health and assembly of the microbial community in the phyllosphere - the total above-ground portions of plants. The work suggests that organisms, from plants to animals, may share a similar strategy to control their microbiomes.

Microbiome studies are a hot topic in human health science. When scientists mention that human 'gut bacteria' should be well balanced, they refer to the gut microbiome, the genetic material of all the microbes living in human digestive systems.

"The field of large-scale plant microbiome study is only about a decade old," said Sheng Yang He, lead co-author of the study, a member of the MSU-DOE Plant Research Laboratory and a Howard Hughes Medical Institute Investigator. "We want to know if plants need a properly assembled phyllosphere microbiome.

Plant genes: Gatekeepers of microbes

"In nature, plants are bombarded by zillions of microbes," said He, a University Distinguished Professor who holds joint appointments in the Department of Plant Biology and the Department of Microbiology and Molecular Genetics in the MSU College of Natural Science. "If everything is allowed to grow in the plants, it would probably be a mess. We want to know if the numbers and types of microbes matter, if there is a perfect composition of microbes. If so, do plants have a genetic system to host and nurture the right microbiome?"

It seems plants do. The newly discovered mechanism involves two genetic networks. One involves the plant immune system and the other controls hydration levels inside leaves. Both networks work together to select which microbes survive inside of plant leaves.

"When we remove both networks from a plant, the microbiome composition inside the leaves changes," He said. "The numbers and mix of bacteria types are abnormal, and our team sees symptoms of tissue damage in plants."

"The symptoms are conceptually like those associated with inflammatory bowel disease in humans," he said. "This is probably because the genes involved are ancient, in evolutionary terms. These genes are found in most plants, while some even have similarities to those involved in animal immunity. "

According to the scientists in the He lab, this may be the first time dysbiosis-associated sickness is formally described in the plant kingdom. The fact it seems conceptually similar to human health suggests a fundamental process in life.

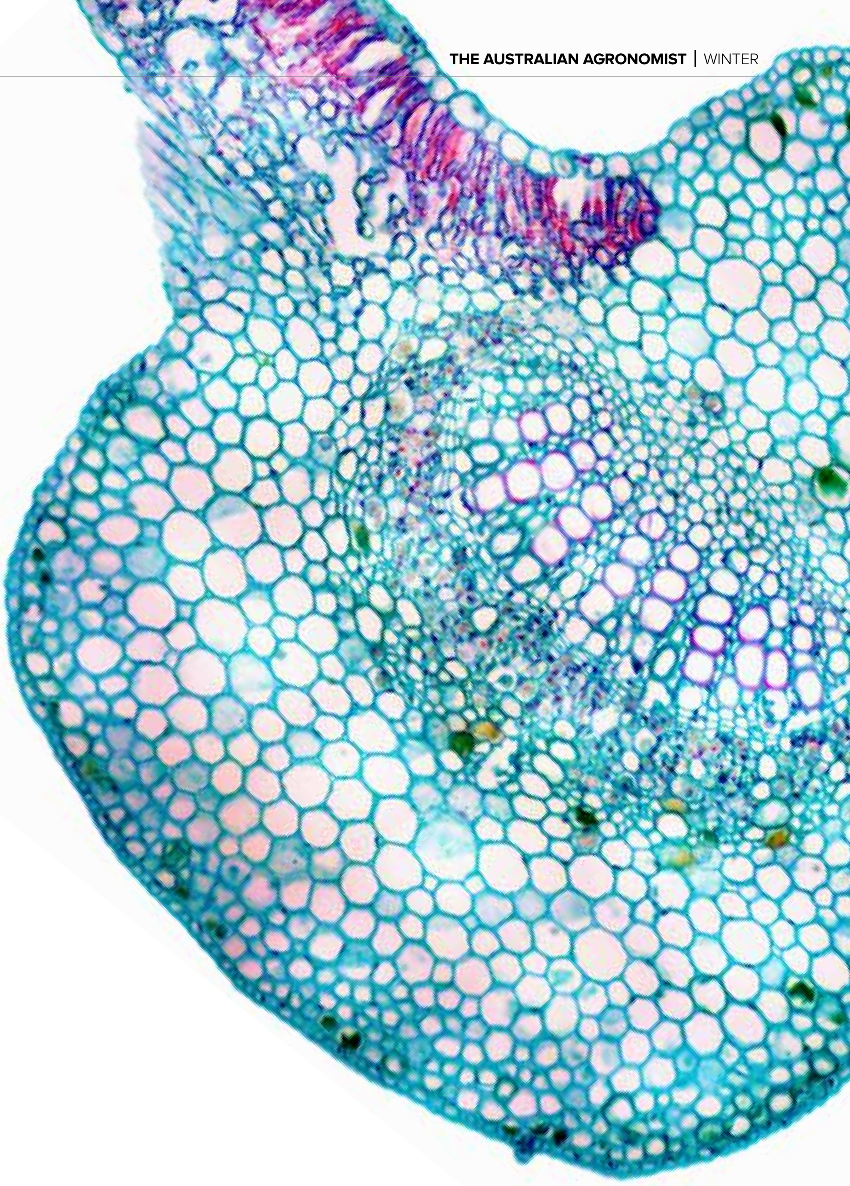
Developing new tech to determine causality

The reason it is difficult to find causality in microbiome studies is because it is practically impossible to cut through the noise of zillions of microbes.

The He lab has worked around this problem by developing a germ-free growth chamber they call the gnotobiotic system - an environment for rearing organisms in which all the microorganisms are either known or excluded.

"Very few people have grown a sterile plant in sterile, organic-rich material," He said. "Our system uses a peat-based soil-like substrate, basically greenhouse potting soil. We use heat and pressure to kill all the germs in the soil, and the plants can grow under this germ-free condition."

Researchers can then introduce microbes in a controlled fashion,



"In nature, plants are bombarded by zillions of microbes, if everything is allowed to grow in the plants, it would probably be a mess. We want to know if the numbers and types of microbes matter, if there is a perfect composition of microbes. If so, do plants have a genetic system to host and nurture the right microbiome?"

Professor Sheng Yang He

into this environment.

"You can add one, two, or even a community of bacteria," He said. "In our study, we extracted a community of bacteria from dysbiotic, or sick, plants and introduced them to our healthy plants, and vice-versa. We found that both the microbiome composition and the plant genetic systems are required for plant health."

For example, a plant with defective genetics could not take advantage of a microbiome transplanted from a healthy plant. The microbiome slowly reverted to the state that caused sickness.

On the other end, a healthy plant exposed to a sick plant's microbiome also suffered. Although it had the genetic tools to select the right microbes, microbe availability was limited and abnormal. The plant couldn't fix the situation.

Microbe levels and composition matter

It turns out that increased microbiome diversity correlates with plant health. Somehow, plant genes are gatekeepers that encourage this diversity.

The sick plants in the study had 100 times more microbes in a leaf, compared to a healthy plant. But the population was less diverse. To figure out why, the scientists did thousands of one-on-one bacteria face-offs to tease out which strains were aggressive.

In the sick plants, proteobacteria strains - many of which are harmful to plants - jumped from two-thirds the composition of a healthy microbiome to 96% in the abnormal population. Fermicutes strains, many which may be helpful to plants, went down in numbers.

"Perhaps, when the population of microbiome is abnormally higher in that sick plant, the microbes are physically too close to each other," He said. "Suddenly, they fight over resources, and the aggressive - in this case harmful - ones unfortunately win. Healthy plants seem to prevent this takeover from happening."

The big picture: Supporting plant health

The study is yet another example of how diversity is important to support healthy living systems. Each type of microbe might impart different benefits to plants, such as increased immunity, stress tolerance or nutrient absorption.

Scientists such as He want to be able to manipulate the plant genetic system to reconfigure the plant microbiome. Plants could become more efficient at selecting their microbial partners and experience improved plant health, resilience, and productivity.

"Our field is still young," He said. "Microbiome research tends to focus on human gut bacteria. But many more bacteria live on plant leaves, the lungs of our planet. It would be wonderful to understand how microbes impact the health of the phyllosphere in natural ecosystems and crop fields."

Journal Reference:

Tao Chen, Kinya Nomura, Xiaolin Wang, Reza Sohrabi, Jin Xu, Lingya Yao, Bradley C. Paasch, Li Ma, James Kremer, Yuti Cheng, Li Zhang, Nian Wang, Ertao Wang, Xiu-Fang Xin, Sheng Yang He. A plant genetic network for preventing dysbiosis in the phyllosphere. Nature, 2020; DOI: 10.1038/s41586-020-2185-0

BIG DATA HELPS FARMERS ADAPT TO CLIMATE VARIABILITY

A new Michigan State University study shines a light on how big data and digital technologies can help farmers better adapt to threats - both present and future - from a changing climate.

The study, published in Scientific Reports, is the first to precisely quantify soil and landscape features and spatial and temporal yield variations in response to climate variability. It is also the first to use big data to identify areas within individual fields where yield is unstable.

Between 2007 and 2016, the U.S. economy took an estimated $536 million economic hit because of yield variation in unstable farmland caused by climate variability across the Midwest. More than one-quarter of corn and soybean cropland in the region is unstable. Yields fluctuate between over-performing and underperforming on an annual basis.

Bruno Basso, MSU Foundation professor of earth and environmental sciences, and his postdoctoral research fellow, Rafael Martinez-Feria, set out to address the key pillars of the National Institute for Food and Agriculture's Coordinated Agricultural Project that Basso has led since 2015.

"First, we wanted to know why - and where - crop yields varied from year to year in the corn and soybean belt of the U.S.," Basso said. "Next, we wanted to find out if it was possible to use big data to develop and deploy climate-smart agriculture solutions to help farmers reduce cost, increase yields and limit environmental impact."

Basso and Martinez-Feria first examined soil and discovered that alone, it could not sufficiently explain such drastic yield variations.

"The same soil would have low yield one year and high yield the next," Basso said. "So, what is causing this temporal instability?"

Using an enormous amount of data obtained from satellites, research aircraft, drones and remote sensors, and from farmers via advanced geospatial sensor suites present in many modern combine harvesters, Basso and Martinez-Feria wove big data and digital expertise together.

What they found is that the interaction between topography, weather and soil has an immense impact on how crop fields respond to extreme weather in unstable areas. Terrain variations, such as depressions, summits and slopes, create localised areas where water stands or runs off. Roughly two-thirds of unstable zones occur in these summits and depressions and the terrain controls water stress experienced by crops.

With comprehensive data and the technology, the team quantified the percentage of every single corn or soybean field in the Midwest that is prone to water excess or water deficit. Yields in water-deficient areas can be 23 to 33% below the field average for seasons with low rainfall but are comparable to the average in very wet years. Areas prone to water excess experienced yields 26 to 33% below field average during wet years.

Basso believes their work will help determine the future of climate-smart agriculture technologies.

"We are primarily concerned with helping farmers see their fields in a new manner, helping them make better decisions to improve yield, reduce cost and improve environmental impact," Basso said.

"Knowing that you have an area shown to be water deficient, you will plan your fertiliser applications differently. The amount of fertiliser for this area should be significantly lower than what you would apply in areas of the same field with more water available to the plants."

The study shines a light on how big data and digital technologies can help farmers better adapt to threats - both present and future - from a changing climate. Photo credit: Michigan State University

Journal Reference:

Rafael A. Martinez-Feria, Bruno Basso. Unstable crop yields reveal opportunities for site-specific adaptations to climate variability. Scientific Reports, 2020; 10 (1) DOI: 10.1038/s41598-020-59494-2

CORN PRODUCTIVITY IN REAL TIME: SATELLITES, FIELD CAMERAS, AND FARMERS TEAM UP

University of Illinois scientists, with help from members of the Illinois Corn Growers Association, have developed a new, scalable method for estimating crop productivity in real time. The research, published in Remote Sensing of Environment, combines field measurements, a unique in-field camera network, and high-resolution, high-frequency satellite data, providing highly accurate productivity estimates for crops across Illinois and beyond.

"Our ultimate goal is to provide useful information to farmers, especially at the field level or sub-field level. Previously, most available satellite data had coarse spatial and/or temporal resolution, but here we take advantage of new satellite products to estimate leaf area index (LAI), a proxy for crop productivity and grain yield. And we know the satellite estimates are accurate because our ground measurements agree," says Hyungsuk Kimm, a doctoral student in the Department of Natural Resources and Environmental Sciences (NRES) at U of I and lead author on the study.

Kimm and his colleagues used surface reflectance data, which measures light bouncing off the Earth, from two kinds of satellites to estimate LAI in agricultural fields. Both satellite datasets represent major improvements over older satellite technologies; they can "see" the Earth at a fine scale (3-meter or 30-meter resolution) and both return to the same spot above the planet on a daily basis. Since the satellites don't capture LAI directly, the research team developed two mathematical algorithms to convert surface reflectance into LAI.

While developing the algorithms to estimate LAI, Kimm worked with Illinois farmers to set up cameras in 36 corn fields across the state, providing continuous ground-level monitoring. The images from the cameras provided detailed ground information to refine the satellite-derived estimates of LAI.

The true test of the satellite estimates came from LAI data Kimm measured directly in the corn fields. Twice weekly during the 2017 growing season, he visited the fields with a specialised instrument and measured corn leaf area by hand.

In the end, the satellite LAI estimates from the two algorithms strongly agreed with Kimm's "ground-truth" data from the fields. This result means the algorithms delivered highly accurate, reliable LAI information from space, and can be used to estimate LAI in fields anywhere in the world in real time.

"We are the first to develop scalable, high-temporal, high-resolution LAI data for farmers to use. These methods have been fully validated using an unprecedented camera network for farmland," says Kaiyu Guan, assistant professor in the Department of NRES and Blue Waters professor at the National Centre for Supercomputing Applications. He is also principal investigator on the study.

Having real-time LAI data could be instrumental for responsive management. For example, the satellite method could detect underperforming fields or segments of fields that could be corrected with targeted management practices such as nutrient management, pesticide application, or other strategies. Guan plans to make real-time data available to farmers in the near future.

"The new LAI technology developed by Dr. Guan's research team is an exciting advancement with potential to help farmers identify and respond to in-field problems faster and more effectively than ever before," says Laura Gentry, director of water quality research for the Illinois Corn Growers Association.

"More accurate measurements of LAI can help us to be more efficient, timely, and make decisions that will ultimately make us more profitable. The last few years have been especially difficult for farmers. We need technologies that help us allocate our limited time, money, and labor most wisely. Illinois Corn Growers Association is glad to partner with Dr. Guan's team, and our farmer members were happy to assist the researchers with access to their crops in validating the team's work. We're proud of the advancement this new technology represents and are excited to see how the Guan research team will use it to bring value directly to Illinois farmers," Gentry adds.

University of Illinois doctoral student Hyungsuk Kimm set up a network of cameras in corn fields around Illinois to ground-truth satellite-based algorithms to monitor corn productivity in real time. Photo credit: Hyungsuk Kimm, University of Illinois.

Journal Reference:

Hyungsuk Kimm, Kaiyu Guan, Chongya Jiang, Bin Peng, Laura F. Gentry, Scott C. Wilkin, Sibo Wang, Yaping Cai, Carl J. Bernacchi, Jian Peng, Yunan Luo. Deriving high-spatiotemporal-resolution leaf area index for agroecosystems in the U.S. Corn Belt using Planet Labs CubeSat and STAIR fusion data. Remote Sensing of Environment, 2020; 239: 111615 DOI: 10.1016/j.rse.2019.111615

DAMAGING IMPACTS OF WARMING MODERATED BY MIGRATION OF RAINFED CROPS

Many studies seek to estimate the adverse effects of climate change on crops, but most research assumes that the geographic distribution of crops will remain unchanged in the future.

New research using 40 years of global data, led by Colorado State University, has found that exposure to rising high temperatures has been substantially moderated by the migration of rainfed corn, wheat and rice. Scientists said continued migration, however, may result in significant environmental costs.

The study, "Climate adaptation by crop migration," was published in March in Nature Communications.

"There's substantial concern about the impacts of climate change on agriculture and how we can adapt to those changes," said Nathan Mueller, assistant professor in the Department of Ecosystem Science and Sustainability at CSU and a senior author on the paper.

"We often think about how farmers can adapt to shifting climate conditions by changing crop varieties or planting dates. But farmers have also been changing what crops they are growing over time, collectively leading to large-scale shifts in crop distribution. This pathway of adaptation has been underexplored."

40 years of data from around the world

Using new, high-resolution datasets on crop areas around the world, the research team analysed the location of crops, climate, and irrigation from 1973 to 2012. They focused on rainfed crops, since they are highly sensitive to changes in temperature and extreme weather.

"We found that on average, over these cropland areas, things are getting warmer," said Mueller, also a researcher in the CSU College of Agricultural Sciences.

The study showed that exposure to increased high temperatures for corn, wheat and rice was much less than it would have been if the crops were positioned where they were in the 1970s.

CSU postdoctoral fellow and first author Lindsey Sloat said this does not mean there is an unlimited capacity for farmers to adapt to climate change by shifting where they grow crops.

"If you add new farmland, that comes with massive environmental consequences," she said. "Land use change in agriculture is one of the biggest drivers of biodiversity loss, with consequences for carbon storage. We can mitigate some of the effects of climate change by increasing irrigation, but there are also environmental costs on that front."

Researchers also found that unlike the other crops, there has been a huge expansion in the production of soybeans, and that these crops are being grown in hotter areas around the world.

Next steps

Sloat said the research team will next delve into analysing other climate variables, moving beyond temperature to consider how changes in a harvested area can alter exposure to other extreme climate conditions.

"Since this migration has been extensive enough in the past to substantially alter exposure to climate trends, we need to think about what our agricultural landscapes are going to look like in the future as warming increases," said Mueller.

Co-authors on the paper include Steven Davis from the University of California, Irvine; James Gerber, Deepak Ray and Paul West from the University of Minnesota; and Frances Moore from the University of California, Davis.

University of Illinois doctoral student Hyungsuk Kimm set up a network of cameras in corn fields around Illinois to ground-truth satellite-based algorithms to monitor corn productivity in real time. Photo credit: Hyungsuk Kimm, University of Illinois.

Journal Reference:

Lindsey L. Sloat, Steven J. Davis, James S. Gerber, Frances C. Moore, Deepak K. Ray, Paul C. West, Nathaniel D. Mueller. Climate adaptation by crop migration. Nature Communications, 2020; 11 (1)
DOI: 10.1038/s41467-020-15076-4

NATIONAL CROP BREEDING ADVOCACY GROUP LAUNCHED

Australia's leading public and private crop breeding organisations have joined forces for the first time to launch a national crop breeding advocacy group called Australian Crop Breeders Ltd (ACB)

Members now include Advanta Seeds, Australian Grain Technologies (AGT), Ag Vic Services (AVS), Elders, InterGrain, LongReach Plant Breeders, Nuseed, PGG Wrightson Seeds, SARDI, SECOBRA Recherches, Seed Force and S&W Seed.

ACB chair Neil Comben said the organisation was created to provide industry advocacy and to facilitate improved communication within the industry.

"Prior to this organisation, every breeder in Australia would engage with the rest of industry as a separate entity, or in loosely formed, subject specific, committees. This meant advocacy was complex and information didn't flow particularly well," he said.

"Now we have a chance to pool our resources, advocate for Australian breeding under one banner and communicate much more effectively."

Crop platforms of current members include cereals, pulses and oilseeds.

The initial areas of focus are End Point Royalties (EPR), National Variety Trials (NVT), research strategy and the Breeders Week event.

Committees have been established to oversee these key areas to create impact at the industry level on behalf of the breeding sector.

"ACB has also taken over responsibility for the coordination of Breeder's Week, an event which is held in March each year."

He said while this week has traditionally been focused around wheat and barley, future events will include topics inclusive of all field crops, such as cereals, pulses and oilseeds.

Mr Comben said ACB membership was open to public and private field crop breeders who are actively breeding for Australian industry.

"We want to encourage every crop breeder to take this opportunity to be connected to the industry."

He said pricing for membership has been set at a very modest level to make the organisation inclusive to smaller breeding programs.

Mr Comben said while there were two membership options available, he strongly urged breeders to take up full membership as opposed to an associate membership to ensure they have full industry engagement.

He said he was looking forward to leading the new group and welcoming more members on board.

"The stronger our membership, the more effective we are as an organisation."

For further information on ACB Ltd or the upcoming Breeders Week in March, please visit the ACB Ltd website at: www.australiancropbreeders.com.au/

From left: Haydn Kuchel (AGT), Tim Sutton (SARDI), David Leah (Seed Force), Tress Walmsley (Intergrain), Troy Keenan - Secretary (InterGrain), Amanda Box (SECOBRA Recherches), Neil Comben - Chairman (Longreach Plant Breeders).

ANCIENT GENOMES COULD LEAD TO CROP IMPROVEMENT

Some 500 million years ago - when our continents were connected in a single land mass and most life existed underwater - hornworts (Anthoceros) were one of the first groups of plants to colonise land. An international team led by University of Zurich (UZH) and the Boyce Thompson Institute has now sequenced three hornwort genomes, providing insights into the genetics underlying the unique biology of the group, an extant representative of the earliest land plants.

The research team began the project in 2011. "It took us three years to figure out how hornworts can be grown and pushed through its sexual life cycle under laboratory conditions, and another three years to properly assemble and annotate its genome," says Péter Szövényi, researcher at UZH and last author of the paper.

Higher crop yields with less fertiliser

One of the researchers' goals was to find genes that play a role in hornworts' method of concentrating carbon dioxide inside chloroplasts, which boosts the plants' ability to make sugar resulting in increased yield. Hornworts are unique among land plants in this capability, but some species of algae share the trait. The researchers thus compared the hornwort genomes with those of algae and found one gene, LCIB, that is shared by the two groups of plants but not with other land plants. "If this carbon-concentrating mechanism could be installed in crop plants, then they could grow larger with the same amount of fertiliser," explains first author Fay-Wei Li, plant biologist at the Boyce Thompson Institute and Cornell University.

Symbiosis with bacteria to acquire nitrogen

Furthermore, hornworts live in symbiosis with fungi and cyanobacteria providing phosphorus and nitrogen to the plant. The researchers also identified 40 genes that may promote the hornworts' source of nitrogen, which comes from an interdependent relationship with cyanobacteria - a unique feature in land plants. "If this capability of hornworts can be transferred to crop plants, many tons of nitrogen fertiliser could be saved," says Szövényi. Such a reduction in fertiliser could benefit the environment, since excess agricultural nitrogen frequently enters waterways, where it can cause deadly algal blooms. Szövényi and Li are already working on a project to understand the genetic mechanism underlying the symbiotic plant-cyanobacteria interaction.

Illuminating the origin of land plants

The research also shed light on the evolution of early land plants. Without stomata, most plants cannot take up carbon dioxide and thrive in the terrestrial environment. Therefore, stomata represent a key innovation in colonisation of the terrestrial environment. Nevertheless, until now it was unknown whether stomata have evolved once or potentially multiple times independently in land plants. Hornworts possess stomata during their spore-producing phase. "We found that the basic genetic toolkit governing stomatal development in flowering plants is shared with hornworts," explains Szövényi. This finding is consistent with the hypothesis that stomata have evolved only once in the most recent common ancestor of land plants.

Hornworts, liverworts and mosses were among the first plants to colonise land, but how the three groups were related had previously not been clear.

"Our research shows clearly that hornworts, liverworts and mosses are all more closely related to each other than they are to vascular plants. We also show that liverworts and mosses are more closely related to each other than to hornworts," says Fay-Wei Li.

Journal Reference:

Fay-Wei Li, Tomoaki Nishiyama, Manuel Waller, Eftychios Frangedakis, Jean Keller, Zheng Li, Noe Fernandez-Pozo, Michael S. Barker, Tom Bennett, Miguel A. Blázquez, Shifeng Cheng, Andrew C. Cuming, Jan de Vries, Sophie de Vries, Pierre-Marc Delaux, Issa S. Diop, C. Jill Harrison, Duncan Hauser, Jorge Hernández-García, Alexander Kirbis, John C. Meeks, Isabel Monte, Sumanth K. Mutte, Anna Neubauer, Dietmar Quandt, Tanner Robison, Masaki Shimamura, Stefan A. Rensing, Juan Carlos Villarreal, Dolf Weijers, Susann Wicke, Gane K.-S. Wong, Keiko Sakakibara, Péter Szövényi. Anthoceros genomes illuminate the origin of land plants and the unique biology of hornworts. Nature Plants, 2020; 6 (3): 259 DOI: 10.1038/s41477-020-0618-2

Hornwort (Anthoceros) grown under laboratory conditions. Photo credit: Eftychis Frangedakis

CROP DIVERSITY CAN BUFFER THE EFFECTS OF CLIMATE CHANGE

How we farm can guard against climate change and protect critical wildlife - but only if we leave single-crop farms in the dust, according to a new Stanford study.

The research provides a rare, long-term look at how farming practices affect bird biodiversity in Costa Rica. "Farms that are good for birds are also good for other species," said Jeffrey Smith, a graduate student in the department of biology and a co-author on the paper. "We can use birds as natural guides to help us design better agricultural systems."

By and large, the team found that diversified farms are more stable in the number of birds they support, provide a more secure habitat for those birds and shield against the impacts of climate change much more effectively than single-crop farms.

"The tropics are expected to suffer even more intensely in terms of prolonged dry seasons, extreme heat and forest dieback under climate change," said Gretchen Daily, director of the Stanford Natural Capital Project and the Centre for Conservation Biology and a senior author on the paper. "But diversified farms offer refuge - they can buffer these harmful effects in ways similar to a natural forest ecosystem."

The findings, published in a recent issue of the journal Nature, highlight the importance of farms that grow multiple crops in a mixed setting instead of the more common practice of planting single-crop "monocultures."

"This study shows that climate change has already been impacting wildlife communities, continues to do so, and that local farming practices really matter in protecting biodiversity and building climate resilience," said Nick Hendershot, a graduate student in the department of biology and lead author on the study.

Threatened in the tropics

Tropical regions are some of the most species-rich in the world, but they also face the greatest threats to biodiversity. As their forests are felled to plant cash crops like bananas and sugarcane, the amount and availability of natural habitats have shrunk dramatically. Meanwhile, climate change has resulted in longer, hotter dry seasons that make species survival even more challenging.

"It's the one-two punch of land-use intensification and climate change," Hendershot said. "Wildlife populations are already severely stressed, with overall decreased health and population sizes in some farming landscapes. Then, these further extreme conditions like prolonged drought can come along and really just decimate a species."

Until now, little had been known about how agricultural practices impact biodiversity in the long term. This study's researchers used nearly 20 years of meticulously collected field data to understand which birds live in natural tropical forests and in different types of farmland.

"It is only because we had these unusually extensive long-term data that we were able to detect the role of diversified farmlands in helping threatened species persist over multiple decades," said Tadashi Fukami, an associate professor of biology in the School of Humanities and Sciences and a senior author on the paper, along with Daily.

The varied agricultural systems at work in Costa Rica provided the research team with an ideal laboratory for studying bird communities in intensively farmed monoculture systems, diversified multi-crop farms, and natural forests. They compared monoculture farms - like pineapple, rice, or sugar cane - to diversified farms that interweave multiple crops and are often bordered by ribbons of natural forest.

Who's there matters

Surprisingly, the researchers found that diversified farmlands not only provide refuge to more common bird species, they also protect some of the most threatened. Species of international conservation concern, like the Great Green Macaw and the Yellow-naped Parrot, are at risk in Costa Rica due to habitat loss and the illegal pet trade.

In intensive monocrop farmlands, these species are declining. But in the diversified systems the researchers studied, the endangered birds can be found year after year.

"Which species are in a given place makes a huge difference - it's not just about numbers alone, we care about who's there," Daily said. "Each bird serves a unique role as part of the machinery of nature. And the habitats they live in support us all."

Changing the paradigm

In Costa Rica and around the world, the researchers see opportunities to develop integrated, diversified agricultural systems that promote not only crop productivity and livelihood security, but also biodiversity. A paradigm shift towards global agricultural systems could help human and wildlife communities adapt to a changing climate, Daily said.

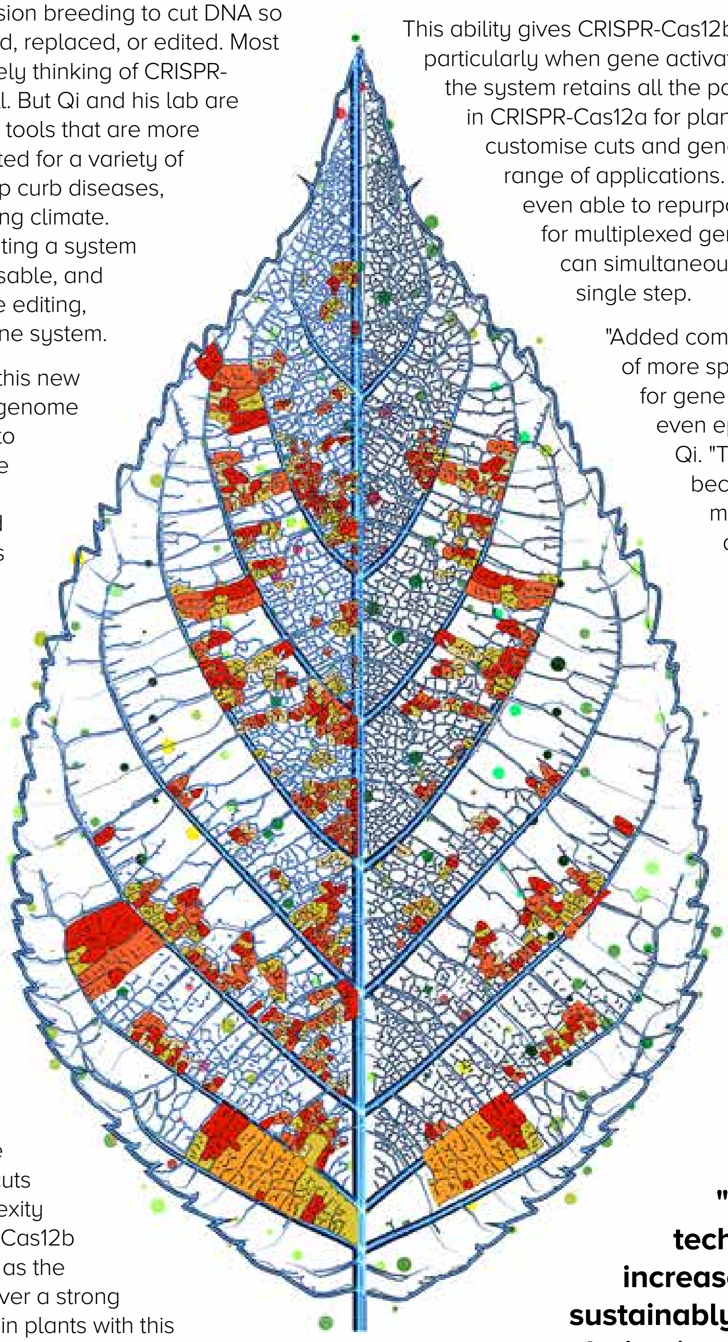
"There are so many cash crops that thrive in diversified farms. Bananas and coffee are two great examples from Costa Rica - they're planted together, and the taller banana plant shades the temperature-sensitive coffee bean," she added. "The two crops together provide more habitat opportunity than just one alone, and they also provide a diversified income stream for the farmer."

Journal Reference:

Hyungsuk Kimm, Kaiyu Guan, Chongya Jiang, Bin Peng, Laura F. Gentry, Scott C. Wilkin, Sibo Wang, Yaping Cai, Carl J. Bernacchi, Jian Peng, Yunan Luo. Deriving high-spatiotemporal-resolution leaf area index for agroecosystems in the U.S. Corn Belt using Planet Labs CubeSat and STAIR fusion data. Remote Sensing of Environment, 2020; 239: 111615 DOI: 10.1016/j.rse.2019.111615

NEW VIABLE CRISPR-CAS12B SYSTEM FOR PLANT GENOME ENGINEERING

In a new publication in Nature Plants, assistant professor of Plant Science at the University of Maryland Yiping Qi has established a new CRISPR genome engineering system as viable in plants for the first time: CRISPR-Cas12b. CRISPR is often thought of as molecular scissors used for precision breeding to cut DNA so that a certain trait can be removed, replaced, or edited. Most people who know CRISPR are likely thinking of CRISPR-Cas9, the system that started it all. But Qi and his lab are constantly exploring new CRISPR tools that are more effective, efficient, and sophisticated for a variety of applications in crops that can help curb diseases, pests, and the effects of a changing climate. With CRISPR-Cas12b, Qi is presenting a system in plants that is versatile, customisable, and ultimately provides effective gene editing, activation, and repression all in one system.



"This is the first demonstration of this new CRISPR-Cas12b system for plant genome engineering, and we are excited to be able to fill in gaps and improve systems like this through new technology," says Qi. "We wanted to develop a full package of tools for this system to show how useful it can be, so we focused not only on editing, but on developing gene repression and activation methods."

It is this complete suite of methods that has ultimately been missing in other CRISPR systems in plants. The two major systems available before this paper in plants were CRISPR-Cas9 and CRISPR-Cas12a. CRISPR-Cas9 is popular for its simplicity and for recognising very short DNA sequences to make its cuts in the genome, whereas CRISPR-Cas12a recognises a different DNA targeting sequence and allows for larger staggered cuts in the DNA with additional complexity to customise the system. CRISPR-Cas12b is more similar to CRISPR-Cas12a as the names suggest, but there was never a strong ability to provide gene activation in plants with this system. CRISPR-Cas12b provides greater efficiency for gene activation and the potential for broader targeting sites for gene repression, making it useful in cases where genetic expression of a trait needs to be turned on/up (activation) or off/down (repression).

"When people think of CRISPR, they think of genome editing, but in fact CRISPR is really a complex system that allows you to target, recruit, or promote certain aspects already in the DNA," says Qi. "You can regulate activation or repression of certain genes by using CRISPR not as a cutting tool, but instead as a binding tool to attract activators or repressors to induce or suppress traits."

This ability gives CRISPR-Cas12b an edge over CRISPR-Cas12a, particularly when gene activation is the goal. Additionally, the system retains all the positives that were inherent in CRISPR-Cas12a for plants, including the ability to customise cuts and gene regulation across a broad range of applications. In fact, Qi and his lab were even able to repurpose the CRISPR-Cas12b system for multiplexed genome editing, meaning that you can simultaneously target multiple genes in a single step.

"Added complexity allows targeting of more specific or other effectors for gene activation, repression, or even epigenetic changes," says Qi. "This system is more versatile because we can play with more modifications, more domains, and there are therefore more opportunities to engineer the whole system. Only when you have this kind of hybrid system with more complexity do you get the most robust gene activation and editing capabilities."

The initial work for CRISPR-Cas12b completed in this paper was conducted in rice, which is already a major global crop. However, Qi and his lab hope to explore more systems to further enhance and improve plant genome engineering, including developing applications to additional crops.

"This type of technology helps increase crop yield and sustainably feed a growing population in a changing world. In the end, we are talking about broad impact and public outreach, because we need to bridge the gap between what researchers are doing and how those impacts affect the world," stresses Qi.

Journal Reference:

Meiling Ming, Qiurong Ren, Changtian Pan, Yao He, Yingxiao Zhang, Shishi Liu, Zhaohui Zhong, Jiaheng Wang, Aimee A. Malzahn, Jun Wu, Xuelian Zheng, Yong Zhang, Yiping Qi. CRISPR-Cas12b enables efficient plant genome engineering. Nature Plants, 2020; DOI: 10.1038/s41477-020-0614-6

TECHNOLOGY TO SCREEN FOR HIGHER-YIELDING CROP TRAITS IS NOW MORE ACCESSIBLE TO SCIENTISTS

LIKE MANY INDUSTRIES, BIG DATA IS DRIVING INNOVATIONS IN AGRICULTURE. SCIENTISTS SEEK TO ANALYSE THOUSANDS OF PLANTS TO PINPOINT GENETIC TWEAKS THAT CAN BOOST CROP PRODUCTION - HISTORICALLY, A HERCULEAN TASK.

To drive progress toward higher-yielding crops, a team from the University of Illinois is revolutionising the ability to screen plants for key traits across an entire field. In two recent studies - published in the Journal of Experimental Botany (JExBot) and Plant, Cell & Environment (PC&E) - they are making this technology more accessible.

"For plant scientists, this is a major step forward," said co-first author Katherine Meacham-Hensold, a postdoctoral researcher at Illinois who led the physiological work on both studies.

"Now we can quickly screen thousands of plants to identify the most promising plants to investigate further using another method that provides more in-depth information but requires more time. Sometimes knowing where to look is the biggest challenge, and this research helps address that."

This work is supported by Realising Increased Photosynthetic Efficiency (RIPE), an international research project that is creating more productive food crops by improving photosynthesis, the natural process all plants use to convert sunlight into energy and yields. RIPE is sponsored by the Bill & Melinda Gates Foundation, the U.S. Foundation for Food and Agriculture Research (FFAR), and the U.K. Government's Department for International Development (DFID).

The team analysed data collected with specialised hyperspectral cameras that capture part of the light spectrum (much of which is invisible to the human eye) that is reflected off the surface of plants. Using hyperspectral analysis, scientists can tease out meaningful information from these bands of reflected light to estimate traits related to photosynthesis.

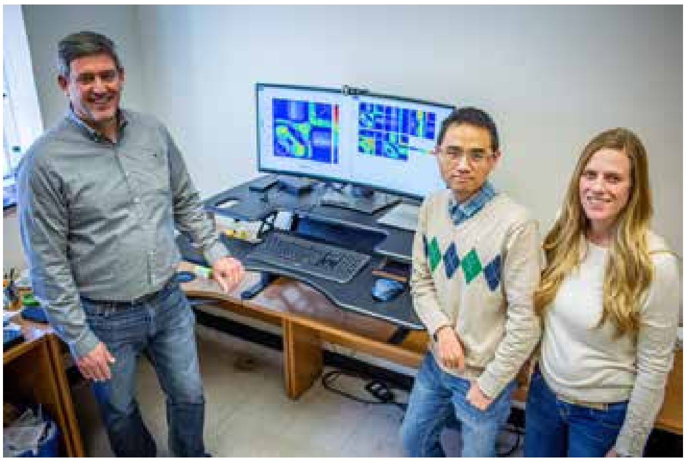
"Hyperspectral cameras are expensive and their data is not accessible to scientists who lack a deep understanding of computational analysis," said Carl Bernacchi, a research plant physiologist with the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS) at the Carl R. Woese Institute for Genomic Biology. "Through these studies, our team has taken a technology that was out of reach and made it more available to our research community so that we can unearth traits needed to provide farmers all over the world with higher-yielding crops."

The RIPE project analyses hundreds of plants each field season. The traditional method used to measure photosynthesis requires as much as 30 minutes per leaf. While newer technologies have increased efficiency to as little as 15 seconds per plant, the study published in JExBot has increased efficiency by an order of magnitude, allowing researchers to capture the photosynthetic capacity of hundreds to thousands of plants in a research plot.

"Now we can quickly screen thousands of plants to identify the most promising plants to investigate further using another method that provides more in-depth information but requires more time. Sometimes knowing where to look is the biggest challenge, and this research helps address that"

Katherine Meacham-Hensold

University of Illinois Research Technician Evan Dracup (left) and Postdoctoral Researcher Katherine Meacham-Hensold (right) use hyperspectral cameras to screen entire research plots for high-yielding photosynthesis traits. Two recent publications are making this technology available to more scientists. Photo credit: Claire Benjamin/RIPE project



USDA-ARS Research Plant Physiologist Carl Bernacchi (left) with Postdoctoral Researchers Peng Fu (middle) and Katherine Meacham-Hensold (right) are working to revolutionize how scientists screen plants for key traits at the field level and making this technology more accessible to other scientists to increase crop yields. Photo credit: Claire Benjamin/RIPE project

In the JExBot study, the team reviewed data from two hyperspectral cameras; one that captures spectra from 400-900 nanometers and another that captures 900-1800 nanometers.

"Our previous work suggested that we should use both cameras to estimate photosynthetic capacity; however, this study suggests that only one camera that captures 400-900 is required," said co-first author Peng Fu, a RIPE postdoctoral researcher who led the computational work on both studies.

In the PC&E study, the team resolved to make hyperspectral information even more meaningful and accessible to plant scientists.

Using just 240 bands of reflectance spectra and a radiative transfer model, the team teased out how to identify seven important leaf traits from the hyperspectral data that are related to photosynthesis and of interest to many plant scientists.

"Our results suggest we do not always need 'high-resolution' reflectance data to estimate photosynthetic capacity," Fu said.

"We only need around 10 hyperspectral bands - as opposed to several hundred or even a thousand hyperspectral bands - if the data are carefully selected. This conclusion can help pave the way to make meaningful measurements with less expensive cameras."

These studies will help us map photosynthesis across different scales from the leaf level to the field level to identify plants with promising traits for further study.

The RIPE project and its sponsors are committed to ensuring Global Access and making the project's technologies available to the farmers who need them the most.

Journal References:

1. Carl Bernacchi, Steven Driever, Taylor Pederson, Evan Dracup, Kaiyu Guan, Elizabeth Ainsworth, Christopher M Montes, Shawn Serbin, Jin Wu, Peng Fu, Katherine Meacham-Hensold. Plot-level rapid screening for photosynthetic parameters using proximal hyperspectral imaging. Journal of Experimental Botany, 2020; DOI: 10.1093/jxb/eraa068

2. Peng Fu, Katherine Meacham- Hensold, Kaiyu Guan, Jin Wu, Carl Bernacchi. Estimating photosynthetic traits from reflectance spectra: A synthesis of spectral indices, numerical inversion, and partial least square regression. Plant, Cell & Environment, 2020; DOI: 10.1111/pce.13718

A MOLECULAR MAP FOR THE PLANT SCIENCES

Every cell of any organism contains the complete genetic information, or the "blueprint," of a living being, encoded in the sequence of the so-called nucleotide building blocks of DNA. But how does a plant create tissues as diverse as a leaf that converts light into chemical energy and produces oxygen, or a root that absorbs nutrients from the soil?

The answer lies in the protein pattern of the cells of the respective tissue. Proteins are the main molecular players in every cell. They are biocatalysts, transmit signals inside and between cells, form the structure of a cell and much more.

"To form the protein pattern, it is not only important which proteins are present in a tissue, but, more importantly, in what quantities," explains Bernhard Kuster, Professor of Proteomics and Bioanalytics at TUM. For example, proteins of the photosynthesis machinery are found primarily in leaves, but also in seeds, yet at a thousand times lower levels.

Laboratory plants as a model for basic research

The team around Dr. Julia Mergner and Professer Bernhard Kuster examined the model plant Arabidopsis thaliana, or thale cress, using biochemical and analytical high-throughput methods to find out more about the molecular composition.

For 40 years, this rather inconspicuous weed with small white flowers has been the "laboratory mouse" of plant biology. It is small, generally undemanding and easy to grow. These properties have paved the way for its frequent us in genetics and molecular biology. The fact that insights from basic research on Arabidopsis can often be transferred to crop plants also makes Arabidopsis interesting for plant breeding research.

Most of the data was generated using a method called liquid chromatography-tandem mass spectrometry, which enables the analysis of thousands of proteins in parallel in one experiment and bioinformatics methods helped analyze the huge amounts of data.

Arabidopsis-Atlas for the global scientific community

"For the first time, we have comprehensively mapped the proteome, that is, all proteins from the tissues of the model plant Arabidopsis," explains Bernhard Kuster. "This allows new insights into the complex biology of plants."

All results of the research work were summarized in a virtual atlas which provides initial answers to the questions:

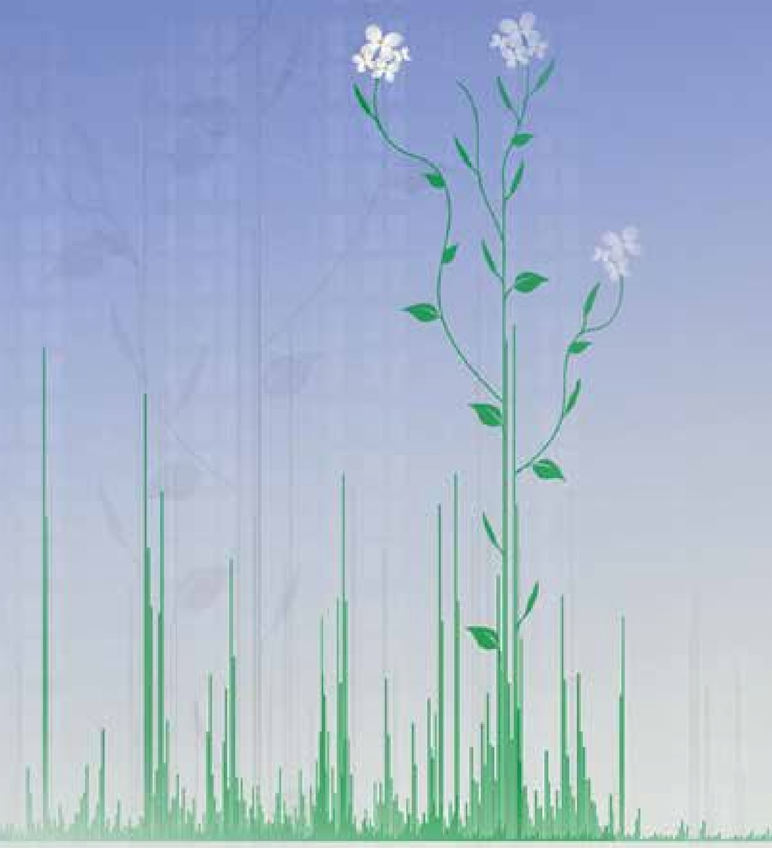
- How many of the approximately 27,000 genes exist in the plant as proteins (> 18,000)?
- Where are they located within the organism (e.g. flower, leaf or stem)?
- In what approximate quantities do they occur?

All data is freely available in the online database ProteomicsDB, which already contains a protein catalog for the human proteome, which the same team at TUM decoded in 2014.

Research results as the basis for future analysis of crop plants

One can anticipate that there are similarities between Arabidopsis and the molecular maps of other plants. "The Atlas should, therefore, also inspire research on other plants," says Kuster.

In the future, the researchers will turn their attention to the analysis of crops. Of particular interest will be to investigate how the proteome changes when plants are attacked by pests or how plants can adapt to climate change.



By mapping more than 18,000 proteins, TUM scientists have created an extensive molecular reference for the popular model plant Arabidopsis thaliana, which is freely accessible via the online database "ProteomicsDB". Photo credit: Chair of Proteomics and Bioanalytics

Journal Reference:

Julia Mergner, Martin Frejno, Markus List, Michael Papacek, Xia Chen, Ajeet Chaudhary, Patroklos Samaras, Sandra Richter, Hiromasa Shikata, Maxim Messerer, Daniel Lang, Stefan Altmann, Philipp Cyprys, Daniel P. Zolg, Toby Mathieson, Marcus Bantscheff, Rashmi R. Hazarika, Tobias Schmidt, Corinna Dawid, Andreas Dunkel, Thomas Hofmann, Stefanie Sprunck, Pascal Falter-Braun, Frank Johannes, Klaus F. X. Mayer, Gerd Jürgens, Mathias Wilhelm, Jan Baumbach, Erwin Grill, Kay Schneitz, Claus Schwechheimer, Bernhard Kuster. Mass-spectrometry-based draft of the Arabidopsis proteome. Nature, 2020; DOI: 10.1038/s41586-020-2094-2

PLANTS PASS ON 'MEMORY' OF STRESS TO SOME PROGENY, MAKING THEM MORE RESILIENT

By manipulating the expression of one gene, geneticists can induce a form of "stress memory" in plants that is inherited by some progeny, giving them the potential for more vigorous, hardy and productive growth, according to Penn State researchers, who suggest the discovery has significant implications for plant breeding.

And because the technique is epigenetic - involving the expression of existing genes and not the introduction of new genetic material from another plant - crops bred using this technology could sidestep controversy associated with genetically modified organisms and food.

"One gene, MSH1, gives us access to what is controlling a broad array of plant resiliency networks," said Sally Mackenzie, professor of plant science in the College of Agricultural Sciences and professor of biology in the Eberly College of Science. "When a plant experiences a stress such as drought or prolonged extreme heat, it has the ability to adjust quickly to its environment to become phenotypically 'plastic' - or flexible."

There are many ways to inactivate the MSH1 gene, researchers explain, and in this context they all work. In well-studied plant species, like Arabidopsis, tomato or rice, it is possible to identify mutations in the gene. In others, and for commercial testing, it is possible to design a transgene that uses "RNA interference" to specifically target MSH1 for gene silencing. Any method that silences MSH1 results in very similar outcomes, they report.

"When plants are modified epigenetically, they can modify many genes in as simple a manner as possible," Mackenzie pointed out. That includes adjusting the circadian clock - detecting light and triggering growth and reproductive phases - and modifying hormone responses to give them maximum flexibility, making them more resilient.

Plants that "detect" stress after the MSH1 gene is silenced can adjust their growth and change root configuration, limit above-ground biomass, delay flowering time and alter their response to environmental stimuli. Those responses are "remembered," researchers reported, and passed in selective breeding through many generations.

"In our research, we show that this memory condition is heritable by progeny but occurs in only a proportion of the progeny - so that there are memory and non-memory full siblings," said Mackenzie, the Lloyd and Dottie Huck Chair for Functional Genomics. "That results in definable gene expression changes that impact a plant's phenotypic 'plasticity.' We suggest that all plants have this capacity, and that the condition that we describe is likely to be an important part of how plants transmit memory of their environment to precondition progeny."

By adjusting the epigenetic architecture of a plant, researchers were able to access its resiliency network, and see how genes are expressed quickly and broadly to adjust a plant's growth to adapt to the environment, noted Mackenzie, director of the Plant Institute at Penn State.

The researchers identify pathways that enhance root growth and plant vigour - increasing yield. They presented their results in May in Nature Communications. When an MSH1-modified plant is crossed or grafted, this enhanced plant vigour becomes quite pronounced.

Researchers contend that plants can be "reprogrammed" epigenetically to express genes differently without altering genotype, which constitutes a non-traditional approach to breeding. Because they can now identify gene networks that appear to be targeted by this manipulation, researchers report that plants have mechanisms designed to address stress or alter growth, and these can be accessed.

The researchers focused their efforts on the small flowering plant, Arabidopsis, or rockcress, a relative of cabbage and mustard in the Brassica family. It is one of the model organisms used for studying plant biology and the first plant to have its entire genome sequenced. Arabidopsis is useful for genetic experiments because of its short generation time and prolific seed production through self-pollination. Researchers grew five generations of Arabidopsis to study "memory" and "non-memory" plants.

In follow-up research already underway in Mackenzie's lab, the researchers have suppressed MSH1 genes in tomato and soybean plants and grafting experiments have been field tested with excellent yield results. A large-scale experiment growing MSH1-modified canola is now in the works. This technology is part of a start-up company called EpiCrop Technologies Inc. that was co-founded on MSH1 technology and its utility in agriculture.

Journal Reference:

Ping Lu, Baiwen Jiang, Jacob Weiner. Crop spatial uniformity, yield and weed suppression. Advances in Agronomy, 2020 DOI: 10.1016/bs.agron.2019.12.003

CROPSCAN 3300H CAPTURES GRAIN CART WEIGHT FROM AGRIMATICS - LIBRA CART WEIGH SCALES

The CropScan 3300H On Combine Analyzer measures Protein, Oil, Starch and Moisture in grains and oil seeds as they are harvested in the field by a combine harvester. Capturing the weight for each grain tank has mainly come from the combine's Yield Monitor.

With the introduction of Grain Cart Weigh Scales and a large uptake of this technology in the last 5 years farmers see the importance of accurate load data to control their grain stocks.

The Agrimatics' Libra Cart Weighing Systems is a leader in this technology using Bluetooth communication to send the weight data to the Libra Cart App. Next Instruments has become a data partner with Agrimatics to integrate the Libra Cart Weigh Scale weight of every grain tank into the Grain Logistics Screen of the CropScan 3300H display.

The CropScan 3300H offers farmers an in cabin Grain Logistics Screen which records the average Protein, Oil, Starch and Moisture for each grain tank. The CropScan-Agrimatics Libra Cart integration now automates the recording of the weight every time grain is transfer into the grain cart.

A Bluetooth interface between the Libra Cart weighing system and the CropScan 3300H display allows the weight of the grain to be recorded automatically. The grain tank weight is collected whenever the grain cart comes alongside the combine and outloads grain into the grain cart.

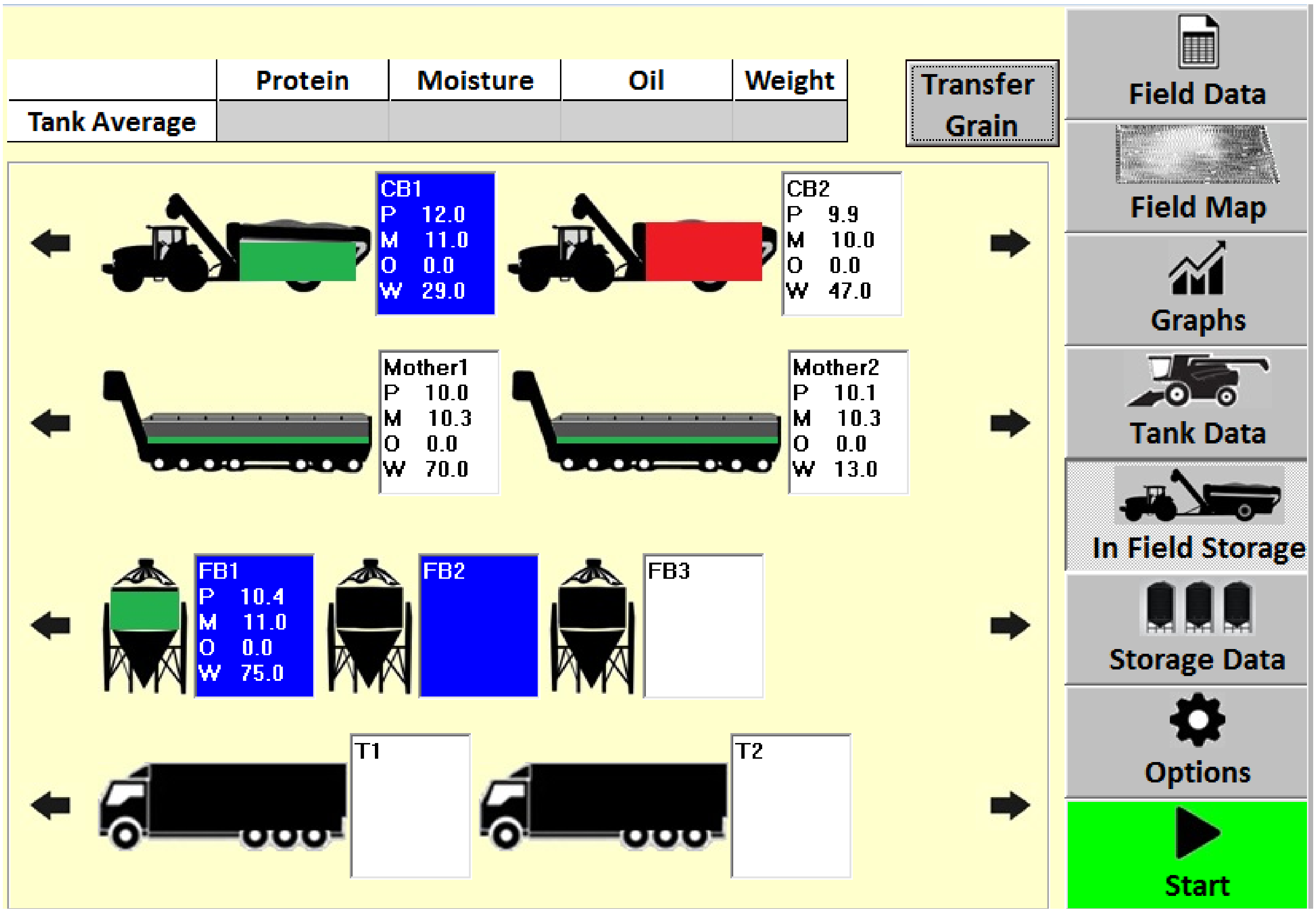
A tare weight for the grain cart is collected prior to out loading and then when the out loading auger is returned, the weight of the cart is taken again. The difference is the actual weight of grain in the cart. The weight for each grain tank and the running accumulation of the grain cart are recorded and displayed in the CropScan 3300H Logistics Screen.

The benefits of using the weight from the grain cart rather than the Yield Monitor is realised when the operator uses the Grain Logistics Screen to manage the quality of the crop as it is harvested.

The greater accuracy provides the farmer with more meaningful and accurate data on the quantity and quality of the crop. The Yield Monitor data is still important because it provides the Protein field maps which then lead to Nitrogen Removal and Nitrogen Use Efficiency maps.

Now farmers have a complete suite of information to manage the storage and marketing of their grains and to better manage the use of Nitrogen fertiliser across the farm.

To learn more about the CropScan 3300H and Grain Logistics operation, visit www.cropscanag.com. Enquiries from farmers and interested parties can be sent to sales@nextinstruments.net or call 02 9771 5444.



COMPARISONS OF ORGANIC AND CONVENTIONAL AGRICULTURE NEED TO BE BETTER, SAY RESEARCHERS

The environmental effects of agriculture and food are hotly debated. But the most widely used method of analysis often tends to overlook vital factors, such as biodiversity, soil quality, pesticide impacts and societal shifts, and these oversights can lead to wrong conclusions on the merits of intensive and organic agriculture. This is according to a trio of researchers writing in the journal Nature Sustainability.

The most common method for assessing the environmental impacts of agriculture and food is Life Cycle Assessment (LCA). Studies using this method sometimes claim that organic agriculture is actually worse for the climate, because it has lower yields, and therefore uses more land to make up for this. For example, a recent study in Nature Communications that made this claim was widely reported by many publications, including the BBC and others.

But according to three researchers from France, Denmark and Sweden, presenting an analysis of many LCA studies in the journal Nature Sustainability, this implementation of LCA is too simplistic, and misses the benefits of organic farming.

"We are worried that LCA gives too narrow a picture, and we risk making bad decisions politically and socially. When comparing organic and intensive farming, there are wider effects that the current approach does not adequately consider," says Hayo van der Werf of the French National Institute of Agricultural Research.

Biodiversity, for example, is of vital importance to the health and resilience of ecosystems. But globally, it is declining, Intensive agriculture has been shown to be one of the main drivers of negative trends such as insect and bird decline. Agriculture occupies more than one-third of global land area, so any links between biodiversity losses and agriculture are hugely important.

"But our analysis shows that current LCA studies rarely factor in biodiversity, and consequently, they usually miss that wider benefit of organic agriculture," says Marie Trydeman Knudsen from Aarhus University, Denmark. "Earlier studies have already shown that organic fields support biodiversity levels approximately 30% higher than conventional fields."

Usage of pesticides is another factor to consider. Between 1990 and 2015, pesticide use worldwide has increased 73%. Pesticide residues in the ground and in water and food can be harmful to human health, terrestrial and aquatic ecosystems, and cause biodiversity losses. Organic farming, meanwhile, precludes the use of synthetic pesticides. But few LCA studies account for these effects.

Land degradation and lower soil quality resulting from unsustainable land management is also an issue - again, something rarely measured in LCA studies. The benefits of organic farming practices such as varied crop rotation and the use of organic fertilisers are often overlooked in LCA studies.

Crucially, LCA generally assesses environmental impacts per kilogram of product. This favours intensive systems that may have lower impacts per kilogram, while having higher impacts per hectare of land.

"LCA simply looks at the overall yields. Of course, from that perspective, it's true that intensive farming methods are indeed more effective. But this is not the whole story of the larger agroecosystem. A diverse landscape with smaller fields, hedgerows and a variety of crops gives other benefits - greater biodiversity, for example," says Christel Cederberg of Chalmers University of Technology, Sweden.

LCA's product-focused approach also fails to capture the subtleties of smaller, diverse systems which are more reliant on ecological processes, and adapted to local soil, climate and ecosystem characteristics. LCA needs a more fine-grained approach.

"We often look at the effects at the global food chain level, but we need to be much better at considering the environmental effects at the local level," says Marie Trydeman Knudsen. The researchers note in their study that efforts are being made in this area, but much more progress is needed.

A further key weakness is when hypothetical "indirect effects" are included, such as assuming that the lower yields of organic agriculture lead to increased carbon dioxide emissions, because more land is needed. For example, another prominent study - from a researcher also based at Chalmers University of Technology - suggested that organic agriculture was worse for the climate, because the requirement for more land leads indirectly to less forest area. But accounting for these indirect effects is problematic.

"For example, consider the growing demand for organic meat. Traditional LCA studies might simply assume that overall consumption of meat will remain the same, and therefore more land will be required. But consumers who are motivated to buy organic meat for environmental and ethical reasons will probably also buy fewer animal-based products in the first place. But hardly any studies into this sort of consumer behaviour exist, so it is very difficult to account for these types of social shifts now," says Hayo van der Werf.

"Current LCA methodology and practice is simply not good enough to assess agroecological systems such as organic agriculture. It therefore needs to be improved and integrated with other environmental assessment tools to get a more balanced picture" says Christel Cederberg.

Journal Reference:

Hayo M. G. van der Werf, Marie Trydeman Knudsen, Christel Cederberg. Towards better representation of organic agriculture in life cycle assessment. Nature Sustainability, 2020; DOI: 10.1038/s41893-020-0489-6

SOME DOMESTICATED PLANTS IGNORE BENEFICIAL SOIL MICROBES

While domestication of plants has yielded bigger crops, the process has often had a negative effect on plant microbiomes, making domesticated plants more dependent on fertiliser and other soil amendments than their wild relatives.

In an effort to make crops more productive and sustainable, researchers recommend reintroduction of genes from the wild relatives of commercial crops that restore domesticated plants' ability to interact with beneficial soil microbes.

Thousands of years ago, people harvested small wild plants for food. Eventually, they selectively cultivated the largest ones until the plump cereals, legumes, and fruit we know today evolved. But through millennia of human tending, many cultivated plants lost some ability to interact with soil microbes that provide necessary nutrients. This has made some domesticated plants more dependent on fertiliser, one of the world's largest sources of nitrogen and phosphorus pollution and a product that consumes fossil fuels to produce.

"I was surprised how completely hidden these changes can be," said Joel Sachs, a professor of biology at UC Riverside and senior author of a paper published recently in Trends in Ecology and Evolution. "We're so focused on above ground traits that we've been able to massively reshape plants while ignoring a suite of other characteristics and have inadvertently bred plants with degraded capacity to gain benefits from microbes."

Bacteria and fungi form intimate associations with plant roots that can dramatically improve plant growth. These microbes help break down soil elements like phosphorus and nitrogen that the plants absorb through their roots. The microbes also get resources from the plants in a mutually beneficial, or symbiotic, relationship. When fertiliser or other soil amendments make nutrients freely available, plants have less need to interact with microbes.

Sachs and first author Stephanie Porter of Washington State University, Vancouver, reviewed 120 studies of microbial symbiosis in plants and concluded that many types of domesticated plants show a degraded capacity to form symbiotic communities with soil microbes.

"The message of our paper is that domestication has hidden costs," Sachs said. "When plants are selected for a small handful of traits like making a bigger seed or faster growth, you can lose a lot of important traits relating to microbes along the way."

This evolutionary loss has turned into a loss for the environment as well.

Excess nitrogen and phosphorus from fertiliser can leach from fields into waterways, leading to algae overgrowth, low oxygen levels, and dead zones. Nitrogen oxide from fertiliser enters the atmosphere, contributing to air pollution. Fossil fuels are also consumed to manufacture fertilisers.

Some companies have begun selling nitrogen-fixing bacteria as soil amendments to make agriculture more sustainable, but Sachs said these amendments don't work well because some domesticated plants can no longer pick up those beneficial microbes from the soil.

"If we're going to fix these problems, we need to figure out which traits have been lost and which useful traits have been maintained in the wild relative," Sachs said. "Then breed the wild and domesticated together to recover those traits."

Journal Reference:

Stephanie S. Porter, Joel L. Sachs. Agriculture and the Disruption of Plant-Microbial Symbiosis. Trends in Ecology & Evolution, 2020; DOI: 10.1016/j.tree.2020.01.006

PLANT WATER SAVING SYSTEM WORKS LIKE CLOCKWORK, IT TRANSPIRES

Plants, just like humans, have circadian clocks that allow them to tell the time. In humans this cellular clockwork influences when we wake and sleep.

Plants are so dependent on daylight that circadian clocks are even more influential, regulating the rate of photosynthesis, gas exchange, and transpiration, which is the flow of water through the stem and evaporation from leaves.

Now researchers have discovered that these biological clocks play a critical role in the consumption of water, allowing plants to use this precious resource more efficiently.

They carried out a series of experiments with model laboratory plants in which the genes encoding circadian rhythms had been changed.

Some changes made plants use more water in relation to growth but, unexpectedly, the experiments revealed that some of these changes to circadian rhythms allowed plants to grow strong and healthily whilst using less water. The study reveals that it is the whole circadian system that affects water use efficiency not just a specific part.

The research opens an opportunity for the tuning of crops to use water more efficiently: losing less water through transpiration whilst still growing.

Agriculture accounts for around 80% of freshwater used worldwide. So, understanding processes in plants that affect the amount of water they use is vitally important to develop crops that are productive but use less water.

Plants transpire water with a daily rhythm because the stomata, tiny pores on the surface of leaves, generally open only in the day. Previous studies showed that daily opening is regulated by circadian rhythms.

"We reasoned that circadian rhythms might have a big impact upon the amount of water that plants use. And our experiments show this to be the case," explains Dr Antony Dodd of the John Innes Centre, who is the senior author of the study.

"The overarching goal of the work lies in reducing the amount of water that is used in crop irrigation to improve the sustainability of agricultural food production."

The study reveals that the altered circadian clock genes affect water use efficiency through a variety of ways. Along with adjusting the process of transpiration, the altered clock influences how big leaves grow which effects how much water the plant uses. These changes together with others account for the improvements in water use efficiency the researchers observed.

The next steps of the study will be to discover the cellular mechanisms that explain how circadian rhythms regulate plant water loss and establish the importance of the findings in key crops, using the knowledge from the model plants used in this study. Further work could involve investigating the role of temperature in how the clock affects water use efficiency.

The research was funded by BBSRC (the GEN ISP at JIC and the SWBio PhD programme in Bristol), and was in collaboration with Prof Alistair Hetherington (University of Bristol).

The circadian clock contributes to the long-term water efficiency of Arabidopsis appears in Plant Physiology journal.

Journal Reference:

Noriane ML Simon, Calum A Graham, Nicholas E Comben, Alistair M. Hetherington, Antony N Dodd. The circadian clock influences the long-term water use efficiency of Arabidopsis. Plant Physiology, 2020; pp.00030.2020 DOI: 10.1104/pp.20.00030

ORGANIC SOYBEAN PRODUCERS CAN BE COMPETITIVE USING LITTLE OR NO TILLAGE

Organic soybean producers using no-till and reduced-tillage production methods that incorporate cover crops - strategies that protect soil health and water quality - can achieve similar yields at competitive costs compared to tillage-based production.

That's the conclusion of a new study by researchers in Penn State's College of Agricultural Sciences. These findings are significant, according to lead researcher John Wallace, assistant professor of weed science, because they may contribute to increased sustainable domestic production of organic soybeans.

The experiment, which focused on finding ways to reduce the intensity or frequency of tillage or soil disturbance in organic field crop production systems, was conducted on certified organic land at Penn State's Russell E. Larson Agricultural Research Center. Researchers compared tillage-based soybean production preceded by a cover crop mixture interseeded into corn, with reduced-tillage soybean production preceded by a roller-crimped cereal rye cover crop that was sown after corn silage.

According to researchers, the reduced-tillage soybean sequence resulted in 50% less soil disturbance compared to the tillage-based soybean sequence across study years, promising substantial gains in water quality and soil conservation. In addition, budget comparisons showed that the reduced-tillage soybean sequence resulted in lower input costs than the tillage-based soybean sequence. However, the reduced-tillage system was about $46US per acre less profitable because of slightly lower average yields.

"Organic grain producers are interested in reducing tillage to conserve soil and decrease labor and fuel costs," Wallace said. "In our research, we examined agronomic and economic tradeoffs associated with alternative strategies for reducing tillage frequency and intensity in a cover crop-soybean sequence, within a corn-soybean-spelt organic cropping system."

Weeds are a serious problem for organic growers of field crops because growers are unable to kill them with herbicides. Significantly, researchers found that weed biomass did not differ between soybean-production strategies. That matters because tillage and cultivation are the primary methods used by organic producers to reduce weeds and other pests.

Tillage-based soybean production marginally increased grain yield by fewer than three bushels per acre compared with the reduced-tillage soybean system.

The study, recently published in Renewable Agriculture and Food Systems, is the latest in a 15-year-long line of organic no-till research conducted in the College of Agricultural Sciences and led by William Curran, professor emeritus of weed science. Although he retired last year, Curran also participated in this study. Organic no-till field crop research continues at Penn State under the direction of Wallace and entomologist Mary Barbercheck.

Finding ways to allow more domestic production of organic soybeans is a huge issue, Wallace contends, because more than 70% of the organic soybeans that feed organically produced poultry in the U.S. are imported. They primarily come from Turkey, India and Argentina.

"There have been many cases of fraudulent imports - crops that were not really produced organically - coming from some of those countries, and that's depressed the premiums that U.S. producers are getting because we're being flooded with these imports," Wallace said. "And they're driving down the prices that U.S. producers can get."

Wallace added that he'd like to help American organic growers, especially those in the Mid-Atlantic region, produce more soybeans using environmentally responsible no-till and reduced-tillage methods.

Cereal rye shown here is being mechanically terminated with a roller-crimper in an organic no-till soybean system. Researchers compared tillage-based soybean production with reduced-tillage soybean production. Photo credit: John Wallace/Penn State

No-till soybeans emerging through roll-crimped cereal rye residue. Photo credit: John Wallace/ Penn State

No-till soybeans following high-residue cultivation, an integrated weed control tactic. Photo credit: John Wallace/Penn State

Journal Reference:

Wallace, J., Isbell, S., Hoover, R., Barbercheck, M., Kaye, J., & Curran, W. (n.d.). Drill and broadcast establishment methods influence interseeded cover crop performance in organic corn. Renewable Agriculture and Food Systems, 1-9. doi:10.1017/S174217052000006X

HOW PLANTS SOUND THE ALARM ABOUT DANGER

This is Arabidopsis thaliana, a small flowering plant in the mustard family. Photo credit: Salk Institute

Just like humans and other animals, plants have hormones. One role of plant hormones is to perceive trouble - whether an insect attack, drought or intense heat or cold - and then signal to the rest of the plant to respond.

A multicentre team led by current and former investigators from the Salk Institute is reporting new details about how plants respond to a hormone called jasmonic acid, or jasmonate. The findings, which were published in Nature Plants in March, reveal a complex communication network. This knowledge could help researchers, such as members of Salk's Harnessing Plants Initiative, develop crops that are hardier and more able to withstand assault, especially in an era of rapid climate change.

"This research gives us a really detailed picture of how this hormone, jasmonic acid, acts at many different levels," says Professor Joseph Ecker, co-corresponding author and Howard Hughes Medical Institute investigator. "It enables us to understand how environmental information and developmental information is processed, and how it ensures proper growth and development."

The plant used in the study was Arabidopsis thaliana, a small flowering plant in the mustard family. Because its genome has been well characterised, this plant is a popular model system. Scientists can take what they learn in A. thaliana and apply it to other plants, including those grown for food. Jasmonic acid is found not only in A. thaliana but throughout the plant kingdom.

"Jasmonic acid is particularly important for a plant's defence response against fungi and insects," says co-first author Mark Zander, a staff researcher in Ecker's lab. "We wanted to precisely understand what happens after jasmonic acid is perceived by the plant. Which genes are activated and deactivated, which proteins are produced and which factors are in control of these well-orchestrated cellular processes?"

The researchers started with plant seeds grown in petri dishes. They kept the seeds in the dark for three days to mimic the first few days of a seed's life, when it is still underground. "We know this growth stage is super important," says co-first author and co-corresponding author Mathew Lewsey, an associate professor at La Trobe University in Melbourne, Australia, who previously worked in Ecker's lab. The first few days in the soil are a challenging time for seedlings, as they face attacks from insects and fungi. "If your seeds don't germinate and successfully emerge from the soil, then you will have no crop," Lewsey adds.

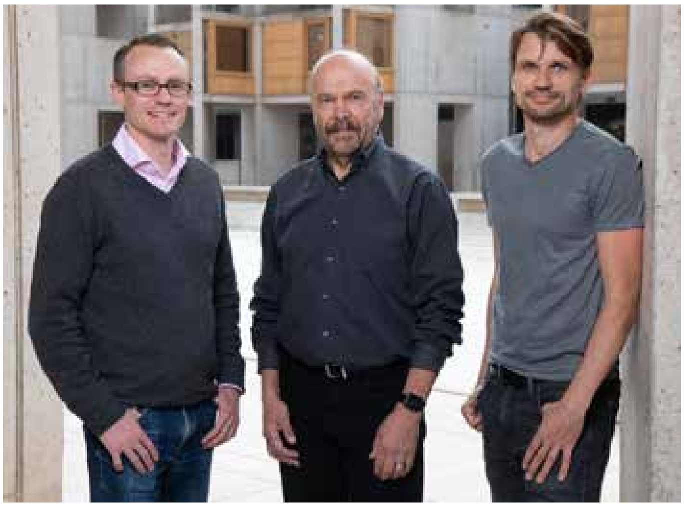
After three days, the plants were exposed to jasmonic acid. The researchers then extracted the DNA and proteins from the plant cells and employed specific antibodies against their proteins of interest to capture the exact genomic location of these regulators. By using various computational approaches, the team was then able to identify genes that are important for the plant's response to jasmonic acid and, moreover, for the cellular cross-communication with other plant hormone pathways.

Two genes that rose to the top in their degree of importance across the system were MYC2 and MYC3. These genes code for proteins that are transcription factors, which means that they regulate the activity of many other genes - or thousands of other genes in this case.

"In the past, the MYC genes and other transcription factors have been studied in a very linear fashion," Lewsey explains. "Scientists look at how one gene is connected to the next gene, and the next one, and so on. This method is inherently slow because there are a lot of genes and lots of connections. What we've done here is to create a framework by which we can analyse many genes at once."

"By deciphering all of these gene networks and subnetworks, it helps us to understand the architecture of the whole system," Zander says. "We now have this very comprehensive picture of which genes are turned on and off during a plant's defence response. With the availability of CRISPR gene editing, these kinds of details can be useful for breeding crops that are able to better withstand attacks from pests."

Another noteworthy aspect of this work is that all of the data from the research has been made available on Salk's website. Researchers can use the site to search for more information about genes they study and find ways to target them.



From left: Mathew Lewsey, Joseph Ecker and Mark Zander. Photo credit: Salk Institute

Journal Reference:

Mark Zander, Mathew G. Lewsey, Natalie M. Clark, Lingling Yin, Anna Bartlett, J. Paula Saldierna Guzmán, Elizabeth Hann, Amber E. Langford, Bruce Jow, Aaron Wise, Joseph R. Nery, Huaming Chen, Ziv Bar-Joseph, Justin W. Walley, Roberto Solano, Joseph R. Ecker. Integrated multi-omics framework of the plant response to jasmonic acid. Nature Plants, 2020; 6 (3): 290 DOI: 10.1038/s41477-020-0605-7

GLOBAL BARLEY VARIETY DOMINATES YIELD AND DEMAND AROUND THE PLANET

RGT PLANET, THE WORLD'S FIRST GLOBAL BARLEY VARIETY, CONTINUES TO DOMINATE NATIONAL VARIETY TRIAL RESULTS AND COMMERCIAL CROP YIELDS ACROSS AUSTRALIA.

RGT Planet, the world's first global barley variety, continues to dominate National Variety Trial results and commercial crop yields across Australia.

Released in Australia to six farmers in 2016 by Seed Force and RAGT, the variety received full malt accreditation in March 2019, taking around 25% market share in that season.

According to Seed Force technical manager, David Leah, the variety continues to perform at the highest levels.

"Developed by our breeding partner RAGT in France, RGT Planet has now been evaluated in some 45 countries around the world and we continue to see strong interest from maltsters and brewers both here and internationally," he said.

"With increasing interest from Australian brewers and those in Asia, we expect demand to grow considerably and for it to be the first choice of Australian barley growers over the next few years."

Aaron McDonald and his father Greg run a 4,500 hectare mixed farming operation at Toolondo in Western Victoria. The family have been farming there for more than 100 years, with Aaron managing the cropping and day-to-day activities, while Greg looks after the sheep.

In 2019, the McDonalds planted 200 hectares of RGT Planet barley, with the support of advisor Matthew Sparke of Sparke Agricultural & Associates.

Systiva seed treatment was used and epoxiconazole fungicide applications were made at GS33 and GS40.

"We sowed around 5 May at 75 kg/ha, with a GoldPhos urea blend with traces at 90 kg," Aaron explained.

"It was top dressed late June with 150 kg of urea and one paddock got 220 kg total in two hits, each a fortnight apart. This particular paddock ended up going around 8.5 t/ha and the rest averaged about 7.5 t/ha."

RGT Planet barley grown by Aaron & Greg McDonald. Photo credit: Seedforce

The McDonalds are storing their RGT Planet harvest on-farm, for use with the sheep and for some to be sold into the market. They are very pleased with how it performed.

"It had excellent vigour and weed competition, and it didn't seem to lodge like some varieties we have grown in the past, even with big amounts of grain on the plant," Aaron continued.

"We also found head retention to be very good. We lost hardly any, when places around Horsham had massive losses last year, mainly with other varieties I think."

Matthew Sparke agreed that the variety suited conditions for the farm.

"RGT Planet's performance in terms of yield and competition,

"Developed by our breeding partner RAGT in France, RGT Planet has now been evaluated in some 45 countries around the world and we continue to see strong interest from maltsters and brewers both here and internationally"

David Leah

along with its water-logging tolerance makes it a standout in high yield wetter environments," he said.

Chris and Kate Sharkey farm 2,000 hectares at Balliang East in Victoria as a cropping and prime lamb operation. As part of their 2019 cropping rotation they planted around 300 hectares of RGT Planet.

"We sowed the crop in May at 75 kg/ha with 50kg/ha of DAP at sowing and 30 litres of UAN at tillering," Chris said.

"We only received 300ml of rain for the year, which was very light on, but when it did rain it came at the right time.

"At harvest, we averaged around 5.5 t/ha across all our RGT Planet, which is well up on the 3 t/ha or so that we'd normally see for barley.

"We just missed malt accreditation. With the high yield taking me a bit by surprise, we didn't apply enough nitrogen to the crop therefore leaving us short on grain protein.

"Having said that, we're really happy with the result. It certainly gave us the best return."

"Speaking with several of our neighbours during harvest, some were seeing yield averages for RGT Planet around 6.5-7 t/ha or a little higher," he said.

"That's pretty amazing for our region. It was interesting to see it was generally across the board, so not just one farm getting these high yields."

Chris says he will plant it again this year.

"We'll be sowing it again this year for sure. It seems perform really well in our conditions.

"It will be interesting to see how it goes with the good moisture we have now, and how the season then pans out."

Aaron & Greg McDonald with stored RGT Planet from 2019 crop. Photo credit: Seedforce

RGT Planet yielded above expectation for Chris Sharkey in 2019. Photo credit: Seedforce

NOVEL CHEMISTRY COULD PROTECT CROPS FROM FUNGAL DISEASE

Pathogenic fungi pose a huge and growing threat to global food security. Currently, we protect our crops against fungal disease by spraying them with anti-fungal chemistries, also known as fungicides.

However, the growing threat of microbial resistance against these chemistries requires continuous development of new fungicides.

A consortium of researchers from the University of Exeter, led by Professor Gero Steinberg, combined their expertise to join the fight against plant pathogenic fungi.

In a recent publication, in the prestigious scientific journal Nature Communications, they report the identification of novel mono-alkyl chain lipophilic cations (MALCs) in protecting crops against Septoria tritici blotch in wheat and rice blast disease.

These diseases challenge temperate-grown wheat and rice, respectively, and so jeopardise the security of our two most important calorie crops.

The scientists' journey started with the discovery that MALCs inhibit the activity of fungal mitochondria.

Mitochondria are the cellular "power-house", required to provide the "fuel" for all essential processes in the pathogen.

By inhibiting an essential pathway in mitochondria, MALCs cut down the cellular energy supply, which eventually kills the pathogen.

Whilst Steinberg and colleagues show that this "mode of action" is common to the various MALCs tested, and effective against plant pathogenic fungi, one MALC that they synthesised and named C18-SMe2+ showed unexpected additional modes of action.

Firstly, C18-SMe2+ generates aggressive molecules inside the mitochondria, which target life-essential fungal proteins, and in turn initiate a "self-destruction" programme, which ultimately results in "cellular suicide" of the fungus.

Secondly, when applied to crop plants, C18-SMe2+ "alerts" the plant defence system, which prepares the crop for subsequent attack, thereby increasing the armoury of the plant against the intruder.

Most importantly, the Exeter researchers demonstrate that C18-SMe2+ shows no toxicity to plants and is less toxic to aquatic organisms and human cells than existing fungicides sprayed used in the field today.

Professor Steinberg said: "It is the combined approach of Exeter scientists, providing skills in fungal cell biology (myself, Dr Martin Schuster), fungal plant pathology (Professor Sarah J. Gurr), human cell biology (Professor Michael Schrader) and synthetic chemistry (Dr Mark Wood) that enabled us to develop and characterise this potent chemistry.

"The University has filed a patent (GB 1904744.8), in recognition of the potential of this novel chemistry in our perpetual fight against fungi.

"We now seek partners/investors to take this development to the field and prove its usefulness under 'real agricultural conditions'. Our long-term aim is to foster greater food security, in particular in developing nations."

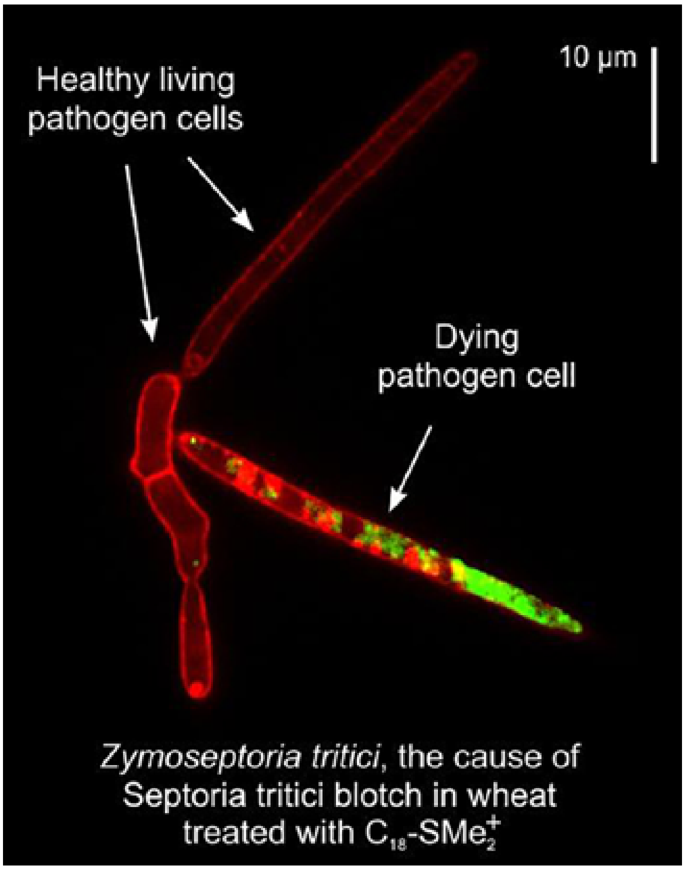
Professor Steinberg added: "I always wanted to apply my research outside of the ivory tower of academia and combine the fundamental aspects of my work with a useful application.

"The visionary approach of the Biological Sciences Research Council (BBSRC) provided me with this opportunity, for which I am very grateful. In my mind, this project is a strong example of translational research that benefits the public."

Professor Sarah Gurr said: "This is such a timely and important study. We are increasingly aware of the growing burden of plant disease caused by fungi and of our need to safe-guard our calorie and commodity crops better.

"The challenge is not only to discover and describe the mode of action of new antifungals but to ensure that chemistries potent against fungi do not harm plants, wildlife or human health.

"This new antifungal is thus an exciting discovery and its usefulness may extend beyond crops into the realms of fungal disease in humans and, indeed to various applications in the paint and preservative industries. This merits investment!"



Zymoseptoria tritici, the cause of Septoria tritici in wheat, treated with C18-SMe2+.
Photo credit: University of Exeter

Journal Reference:

Steinberg, G., Schuster, M., Gurr, S.J. et al. A lipophilic cation protects crops against fungal pathogens by multiple modes of action. Nat Commun 11, 1608 (2020). https://doi.org/10.1038/s41467-020-14949-y

MICROBES PLAY IMPORTANT ROLE IN SOIL'S NITROGEN CYCLE

Many studies seek to estimate the adverse effects of climate change on crops, but most research assumes that the geographic distribution of crops will remain unchanged in the future.

New research using 40 years of global data, led by Colorado State University, has found that exposure to rising high temperatures has been substantially moderated by the migration of rainfed corn, wheat and rice. Scientists said continued migration, however, may result in significant environmental costs.

The study, "Climate adaptation by crop migration," was published in March in Nature Communications.

"There's substantial concern about the impacts of climate change on agriculture and how we can adapt to those changes," said Nathan Mueller, assistant professor in the Department of Ecosystem Science and Sustainability at CSU and a senior author on the paper.

"We often think about how farmers can adapt to shifting climate conditions by changing crop varieties or planting dates. But farmers have also been changing what crops they are growing over time, collectively leading to large-scale shifts in crop distribution. This pathway of adaptation has been underexplored."

40 years of data from around the world

Using new, high-resolution datasets on crop areas around the world, the research team analysed the location of crops, climate, and irrigation from 1973 to 2012. They focused on rainfed crops, since they are highly sensitive to changes in temperature and extreme weather.

"We found that on average, over these cropland areas, things are getting warmer," said Mueller, also a researcher in the CSU College of Agricultural Sciences.

The study showed that exposure to increased high temperatures for corn, wheat and rice was much less than it would have been if the crops were positioned where they were in the 1970s.

CSU postdoctoral fellow and first author Lindsey Sloat said this does not mean there is an unlimited capacity for farmers to adapt to climate change by shifting where they grow crops.

"If you add new farmland, that comes with massive environmental consequences," she said. "Land use change in agriculture is one of the biggest drivers of biodiversity loss, with consequences for carbon storage. We can mitigate some of the effects of climate change by increasing irrigation, but there are also environmental costs on that front."

Researchers also found that unlike the other crops, there has been a huge expansion in the production of soybeans, and that these crops are being grown in hotter areas around the world.

Next steps

Sloat said the research team will next delve into analysing other climate variables, moving beyond temperature to consider how changes in a harvested area can alter exposure to other extreme climate conditions.

"Since this migration has been extensive enough in the past to substantially alter exposure to climate trends, we need to think about what our agricultural landscapes are going to look like in the future as warming increases," said Mueller.

Co-authors on the paper include Steven Davis from the University of California, Irvine; James Gerber, Deepak Ray and Paul West from the University of Minnesota; and Frances Moore from the University of California, Davis.

Nodules forming on the root of a soybean plant. These nodules will give a home to soil microbes in exchange for nitrogen. Photo credit: Vivian Wauters

Journal Reference:

Xinda Lu, Anne E. Taylor, David D. Myrold, Josh D. Neufeld. Expanding perspectives of soil nitrification to include ammonia-oxidizing archaea and comammox bacteria. Soil Science Society of America Journal, 2019; DOI: 10.1002/saj2.20029

UNIVERSALLY POSITIVE EFFECT OF COVER CROPS ON SOIL MICROBIOME

ONLY A FRACTION OF CONVENTIONAL ROW CROP FARMERS GROW COVER CROPS AFTER HARVEST, BUT A NEW GLOBAL ANALYSIS FROM THE UNIVERSITY OF ILLINOIS SHOWS THE PRACTICE CAN BOOST SOIL MICROBIAL ABUNDANCE BY 27%.

The result adds to cover crops' reputation for nitrogen loss reduction, weed suppression, erosion control, and more. Although soil microbial abundance is less easily observed, it is a hugely important metric in estimating soil health.

"A lot of ecological services are done by the soil microbiome, including nutrient cycling. It's really important to understand how it functions and how agriculture can form a healthier soil microbiome," says Nakian Kim, doctoral student in the Department of Crop Sciences at the University of Illinois and lead author on a new paper in Soil Biology and Biochemistry.

Other studies have shown benefits of cover cropping on the soil microbial community, but most of them have been one-offs influenced by specific site conditions, unique seasonal effects, idiosyncratic management regimes, and the researchers' chosen analysis methods. Kim's work is different in that he looked for universal patterns among dozens of these one-off studies.

"Our analysis shows that across 60 field studies, there was a consistent 27% increase in microbial abundance in fields with cover crops versus no cover crops. It's across all these studies from around the world," says Maria Villamil, associate professor in crop sciences and co-author on the paper.

The research team performed a search of the existing studies on cover crops, and wound up with some 985 scientific articles. Of these, they only kept studies that directly compared cover crops and bare fallow soils, and omitted studies conducted in greenhouses or that treated crop residues as cover crops. They also ensured that the studies were statistically sound, with reasonably large sample sizes. In the end, they mined and reanalysed data from 60 studies reporting on 13 soil microbial parameters.

"That's why the criteria of selection had to be so strict. We wanted to compare studies that were solid, and with enough replications that we could make valid claims about global patterns," Villamil says.

The research team divided the 13 microbial parameters into three categories: microbial abundance, activity, and diversity. Microbial abundance wasn't the only category to show a significant increase with cover cropping compared to bare fallow soils. Microbial activity was also up 22%, and diversity increased 2.5%.

"All the categories are important, but especially diversity, because a diverse microbiome is more resilient. Considering the close linkage between microbial diversity and the provision of ecosystem services, small impacts could go a long way to increase sustainability. In that sense, I think the cover crops are really helping," Kim says.

"Our analysis shows that across 60 field studies, there was a consistent 27% increase in microbial abundance in fields with cover crops versus no cover crops. It's across all these studies from around the world"
Maria Villamil

Cover crops such as ryegrass can boost soil microbiome by 27%, according to a University of Illinois meta-analysis. Photo credit: Maria Villamil, University of Illinois

The researchers were also able to tease out several factors that layered on top of the main effect of cover crops. For example, how did climate, cover crop termination method, or tillage regime affect the ability of the cover crops to benefit the soil microbial community?

Kim says the use of burndown herbicides as a cover crop termination method had a strong moderating effect on the microbial community. "The results were very interesting. With chemical termination, the effect sizes were consistently smaller compared to mechanical termination. In other words, the benefits from the cover crops are diminished somehow from the herbicides. I think that's one big takeaway."

Tillage also made a difference, according to Kim. He expected conventional tillage to reduce the effect of cover crops on the soil microbes, but instead, conservation tillage did that. "My guess is that because conservation tillage included not tilling at all, that allowed weeds to grow on the land. The weeds could have mimicked what the cover crops do. So the difference between the control treatment and the cover crop may decrease because of the weeds."

Because their effects were indirect, these secondary factors need more research before real claims can be made. Villamil's research team already has studies in the works to get more definitive answers. But in the meantime, she's heartened by the results of the analysis as a whole.

"For me, it was surprising to see the consistent, positive effect of cover crops - surprising but good. Finally! I've been researching cover crops in our typical corn-soybean rotations in Illinois since 2001, yet in these high-fertility environments, it has proven difficult to show any effects beyond cereal and annual rye capturing nitrogen (weather permitting). Changes in chemical and physical properties related to cover crop use are difficult to see," Villamil says. "But the microbiome, that's where it's at. That's how everything is related. Thanks to this work, I have something to look forward to when I put in cover crops, and have generated many more questions in need of research."

Journal Reference:

Nakian Kim, María C. Zabaloy, Kaiyu Guan, María B. Villamil. Do cover crops benefit soil microbiome? A meta-analysis of current research. Soil Biology and Biochemistry, 2020; 142: 107701 DOI: 10.1016/j.soilbio.2019.107701

NEW TOOL TO COMBAT MAJOR WHEAT DISEASE

US Agricultural Research Service (ARS) scientists and their colleagues have discovered a gene that can be used to develop varieties of wheat that will be more resistant to Fusarium Head Blight (FHB), a disease that is a major threat both overseas and to the nation's US$10 billion annual wheat crop.

A paper reporting the discovery and the cloning of the gene, known as Fhb7, was published recently in the journal Science. The study was led by scientists at the Shandong Agricultural University in Shandong, China and co-authors include ARS researchers Guihua Bai and Lanfei Zhao in Manhattan, Kansas, and Steven Xu in Fargo, North Dakota.

The discovery is a major advance in addressing a significant threat to the world's wheat supply. FHB, also known as "scab," is caused by a fungal pathogen, Fusarium graminearum, and results in significant losses in the United States, China, Canada, Europe, and many other countries. It also attacks barley and oats.

When the pathogen grows unchecked in infected grains, it releases mycotoxins that can induce vomiting in humans, as well as weight loss in livestock when they refuse to eat the grains.

The prevalence and severity of FHB outbreaks also could potentially be exacerbated by climate change and varying weather conditions, and by an increasing trend toward more corn production and no-till farming, which both may be increasing the prevalence of the pathogen in fields. Growers often must use fungicides to reduce FHB damage.

The researchers found that the gene effectively reduces FHB by detoxifying the mycotoxins secreted by the pathogen. The gene also confers resistance to crown rot, a wheat disease caused by a related pathogen.

The researchers originally identified the gene in Thinopyrum wheatgrass, a wild relative of wheat that has been previously used to develop varieties of wheat with beneficial traits, such as rust resistance and drought tolerance. They cloned the gene and introduced it into seven wheat cultivars with different genetic profiles to study its effects on plants grown under field conditions.

The results showed that the gene not only conferred resistance to scab in the new plants, but it also had no negative effects on yield or other significant traits.

The study sheds new light on the molecular mechanisms that can make wheat, as well as barley and oats, resistant to the pathogen that causes FHB. New varieties of wheat with better FHB resistance using Fhb7 are expected to be available in a few years, the researchers say.

White heads of wheat caused by Fusarium crown rot. Photo credit: CSIRO

Journal Reference:

Hongwei Wang, Silong Sun, Wenyang Ge, Lanfei Zhao, Bingqian Hou, Kai Wang, Zhongfan Lyu, Liyang Chen, Shoushen Xu, Jun Guo, Min Li, Peisen Su, Xuefeng Li, Guiping Wang, Cunyao Bo, Xiaojian Fang, Wenwen Zhuang, Xinxin Cheng, Jianwen Wu, Luhao Dong, Wuying Chen, Wen Li, Guilian Xiao, Jinxiao Zhao, Yongchao Hao, Ying Xu, Yu Gao, Wenjing Liu, Yanhe Liu, Huayan Yin, Jiazhu Li, Xiang Li, Yan Zhao, Xiaoqian Wang, Fei Ni, Xin Ma, Anfei Li, Steven S. Xu, Guihua Bai, Eviatar Nevo, Caixia Gao, Herbert Ohm, Lingrang Kong. Horizontal gene transfer of Fhb7 from fungus underlies Fusarium head blight resistance in wheat. Science, 2020; eaba5435 DOI: 10.1126/science.aba5435

BUILDING BETTER BALES WITH BALE BOOST

As an introduction, Vicchem is Australia's leading adjuvant company producing Hasten, widely recognised by many Australian and international farmers as a premium spray adjuvant. In 2020 Vicchem is launching a range of products under the Bale Boost brand for the ever-expanding quality hay industry. In this newsletter, Vicchem would like to introduce our new products, Hayspray 300, Bale Shield, Drydown 550 and Leaf Retain 990.

Marketed under the Bale Boost Range, Vicchem's new products aim to address some of the challenges producers face when making high-quality hay.

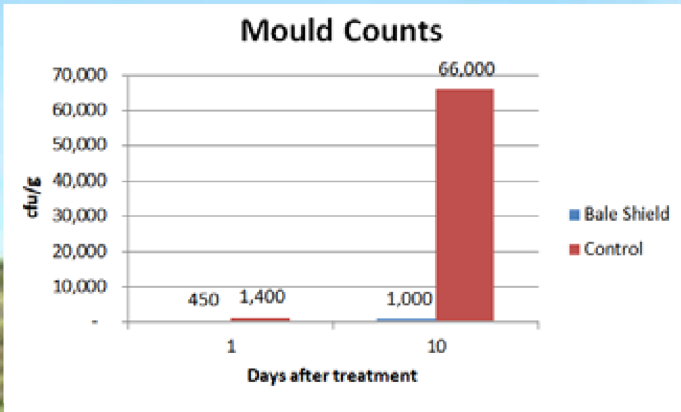
Hayspray 300

The ability to evenly apply chemicals directly into a hay windrow has until now been virtually non-existent. Hayspray 300 is Vicchem's brand new technology allowing applications of products into a hay windrow using patented air blast technology to successfully apply products throughout a hay windrow profile.

Bale Shield

This means that Bale Shield, Vicchem's new buffered propionic based preservative can now be applied immediately after hay cutting, before moulds have the opportunity to multiply rapidly. Early applications of preservatives can significantly decrease the rate of mould spore growth.

A trial in 2019 showed that after 10 days, cfu/g counts in untreated hay were 66,000 cfu/g while Bale Shield treated levels were only at 1,000 cfu/g a whopping differential. Targeting moulds earlier offers opportunities to minimise mould development and the potential for spoilt hay or in worsed case scenario, fires.



Dry Down 550

Faster drying hay is a very important tool for minimising weather risks and decreases the time hay is exposed to adverse weather conditions. Based on Vicchem's 80 years of knowledge and experience in drying grapes, newly developed Dry Down, as it name implies, is applied to freshly cut hay to speed up the drying process. How much faster is the most common question, while there can be no guarantees because of the many variables that influence drying rates, trials in 2019 continued to demonstrate beneficial results.

At day 7, Dry Down treated Irrigated Oaten hay windrows were 36% drier than untreated hay; while Vetch at 10 days post cutting/ treatment the Dry Down windrows were on average was 46% drier than untreated. Mother Nature is still required to be on your side to facilitate the process and adverse weather conditions will affect the results, but Vicchem now offer a very valuable assistant to the process.

Leaf Retain 990

The third product in the Bale Boost range is used in conjunction with the Hayspray unit and applied to the windrow ahead of the baler and as its name implies helps to minimise leaf shatter. It softens and returns the leaf and fine stems to a supple state temporarily to minimise losses at the pickup in particular. This product has been used extensively by an irrigated hay grower in Victoria on both legumes and oaten hay, allowing higher yields and extended baling hours in hot dry conditions.

For more information, please contact our Hay product specialist Steve Williams on 0427 632 097 or visit Vicchem website for the 8-page brochure at www.vicchem.com

HAYSPRAY 300 PROTOTYPE UNIT

REDUCING RELIANCE ON NITROGEN FERTILISERS WITH BIOLOGICAL NITROGEN FIXATION

Crop yields have increased substantially over the past decades, occurring alongside the increasing use of nitrogen fertiliser. While nitrogen fertiliser benefits crop growth, it has negative effects on the environment and climate, as it requires a great amount of energy to produce. Many scientists are seeking ways to develop more sustainable practices that maintain high crop yields with reduced inputs.

"A more sustainable way to provide nitrogen to crops would be through the use of biological nitrogen fixation, a practice well developed for leguminous crops," says plant pathologist Gary Stacey of the University of Missouri. "A variety of nitrogen fixing bacteria are common in the rhizosphere of most plants. However, such plant growth promoting bacteria (PGPB) have seen only limited use as inoculants in agriculture."

Stacey and his college believe that this limited use is due to the general problems associated with the use of biologicals for crop production and variable efficacy upon application. They conducted research to gain a greater understanding of the metabolic response of the plant host in order to reduce the variability seen with the response of crops to PGPB.

"One challenge with our research is that, while PGPB can colonise roots to high levels, the sites of colonisation can be highly localised," said Stacey. "Hence, isolating whole roots results in a considerable dilution of any signal due to the great majority of the root cells not in contact with the bacteria."

To overcome this challenge, Stacey and his team utilised laser ablation electrospray ionization mass spectrometry (LAESI-MS), which allowed them to sample only those sites infected by the bacteria, which they could localised due to expression of green fluorescent protein.

Their results showed that bacterial colonisation results in significant shifts in plant metabolism, with some metabolites more significantly abundant in inoculated plants and others, including metabolites indicative of nitrogen, were reduced in roots uninoculated or inoculated with a bacterial strain unable to fix nitrogen.

"Interestingly, compounds, involved in indole-alkaloid biosynthesis were more abundant in the roots colonised by the fix- strain, perhaps reflecting a plant defence response," said Stacey. "Ultimately, through such research, we hope to define the molecular mechanisms by which PGPB stimulate plant growth so as to devise effective and consistent inoculation protocols to improve crop performance."

Stacey's lab has long been interested in biological nitrogen fixation and plant-microbe interactions in general. Since the discovery of biological nitrogen fixation (BNF), the lab has had a goal to convey the benefits of BNF to non-leguminous crops such as maize. PGPB have this ability in nature but this has not been adequately captured for practical agricultural production.

"We believe that, in contrast to other better studied interactions, such as rhizobium-legume, this is due to a general lack of information about the molecular mechanisms by which PGPB stimulate plant growth. Hence, we have undertaken in our lab projects that seek to provide this information in the belief that such information will increase the efficacy of PGPG inoculants with the net effect to increase their use for crop production."

Stacey and his team were most surprised to find that they did not see a significant impact on phytohormone production that correlated tightly with the ability of PGPB to enhance plant growth. This suggests that PGPB impact plant metabolism to a greater extent than previously realised, pointing perhaps to more complex explanations for how these bacteria impact plant growth.

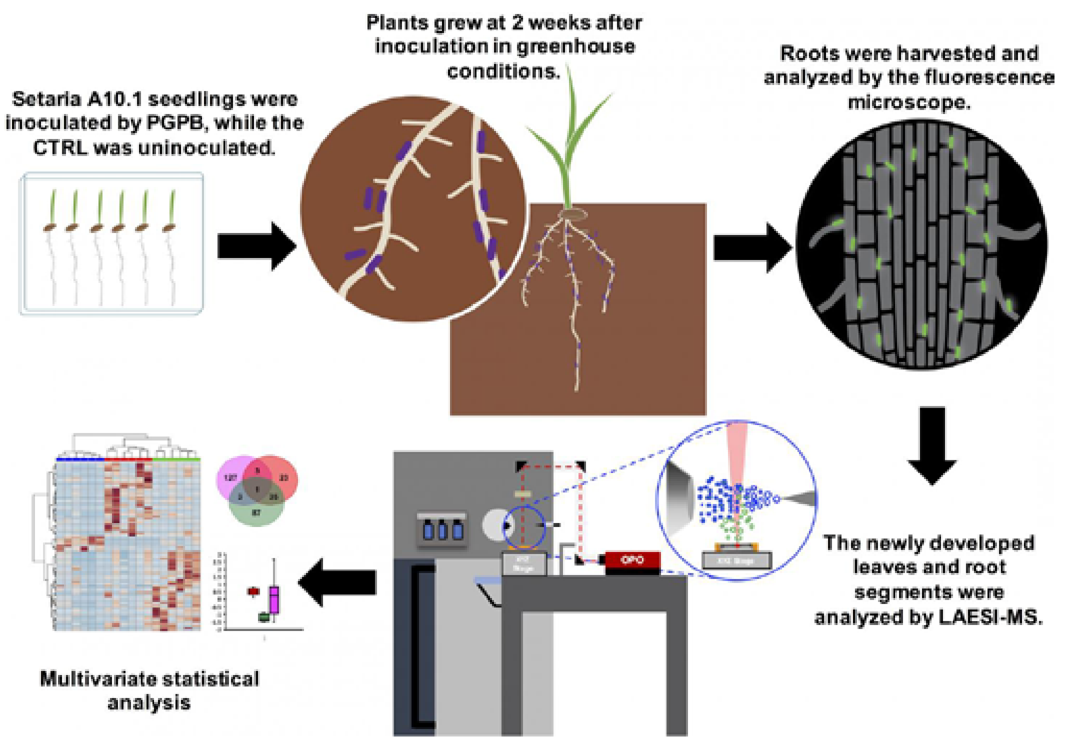


Image:
Three-day-old seedlings of Setaria viridis A10.1 were inoculated with either Herbaspirillum seropedicae SmR1 (fix+) or SmR54 (fix?), while the control (CTRL) plants were uninoculated. The plants grew for 2 weeks after inoculation under greenhouse conditions. The roots and leaves were harvested. Roots from plants that were inoculated with SmR1 or SmR54 were analyzed by fluorescence microscopy. Photo credit: Beverly J. Agtuca, Sylwia A. Stopka, Thalita R. Tuleski, Fernanda P. do Amaral, Sterling Evans, Yang Liu, Dong Xu, Rose Adele Monteiro, David W. Koppenaal, Ljiljana Paša-Toli?, Christopher R. Anderton, Akos Vertes, and Gary Stacey

Journal Reference:

Beverly J. Agtuca, Sylwia A. Stopka, Thalita R. Tuleski, Fernanda P. do Amaral, Sterling Evans, Yang Liu, Dong Xu, Rose Adele Monteiro, David W. Koppenaal, Ljiljana Paša-Toli- , Christopher R. Anderton, Akos Vertes, Gary Stacey. In-Situ Metabolomic Analysis of Setaria viridis Roots Colonized by Beneficial Endophytic Bacteria. Molecular Plant-Microbe Interactions®, 2020; 33 (2): 272
DOI: 10.1094/MPMI-06-19-0174-R

CLOSING THE YIELD GAP

BY PHILLIP CLANCY

AGRONOMISTS AND AG SCIENTISTS AROUND THE WORLD HAVE KNOWN FOR MORE THAN 50 YEARS THAT YIELD AND PROTEIN IN CEREAL GRAINS ARE CLOSELY RELATED. APPLYING MORE NITROGEN TO WHEAT OR BARLEY CROPS WILL PRODUCE A POSITIVE RESPONSE IN YIELD WHEN THE PROTEIN CONTENT IS LESS THAN 11.5%.

So what does this mean?

Both Yield and Protein vary considerably across fields. For wheat, Yield can vary from 0.5 to 12+ T/ha and Protein can vary from 6 to 18%. However when the final grains contain less than 11.5% (approximately) then the full Yield Potential was not achieved. If more Nitrogen fertilizer had been applied into the field zones where the Protein is less than 11.5%, then the Yield would have been higher.

The graph[1] shows the response of Yield and Protein to adding Nitrogen fertilizer onto strip trials of 10 varieties of wheat at Trangie, NSW, in 2012. The plot shows that at approximately 90kg/ha additional Nitrogen the Yield reaches a maximum. Adding more Nitrogen increases the Protein content but does not increase the Yield. When the Full Yield Potential is achieved and the Protein content is optimized for the use of the grain, then this is the "Sweet Spot" in how much fertilizer should be added.

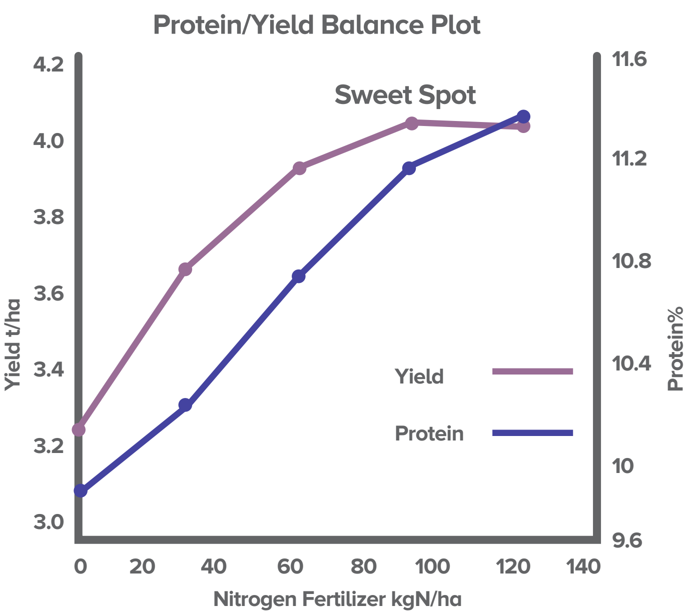


Fig 3. Grain yield (t/ha) and protein concentration (%) from 10 wheat varieties with 0, 30, 60, 90, and 120 kg/ha applied nitrogen in a trial at Parkes in 2011. (Brill et al, 2012, Comparison-of-grain-yield-and-grain-protein-concentration-of-commercial-wheat-varieties)

The implication of the Protein/Nitrogen/Yield Balance is that farmers have the potential to increase Yield and thereby increase their productivity and profitability by applying Nitrogen fertilizer into those zones in the field where the Protein is low. Till now farmers have been able to measure Yield but not Protein. The CropScan 3300H On Combine NIR Grain Analyser provides the Protein layer necessary to understand the availability and uptake of Nitrogen across the field.

What is economic opportunity of increasing Yield in cereal crops around the world?

In Australia the average Yield in cereal crops is 1.7T/ha while the Yield Potential is 3.4T/ha.[2] Therefore the Yield Gap is 1.7T/ha. Australia produces around 25million tonne of wheat and 6million tonne of barley per year depending on droughts. Reducing the Yield Gap to zero over a period of time would double production and revenues for farmers. Table 1 show the potential economic impact of reducing the Yield Gap to zero over a period of time..

Reduction in Yield Gap	Current Value @$300/T	Yield Gap 40%	Yield Gap 30%	Yield Gap 20%	Yield Gap 10%	Yield Gap 0%
Wheat Tonnage	25 MTonne	30 MTonne	35 MTonne	40 MTonne	45 MTonne	50 MTonne
Wheat Value $billion	A$7.5	A$9.0	A$10.5	A$12.0	A$13.5	A$15.0
Barley Tonnage	6 MTonne	7.2 MTonne	8.4 MTonne	9.6 MTonne	10.8 MTonne	12.0 MTonne
Barley Value $billion	A$1.8	A$2.16	A$2.52	A$2.88	A$3.24	A$3.6
Total Increase T	31 MTonne	6.2 MTonne	12.4 MTonne	18.6 MTonne	24.8 MTonne	31 MTonne
Total Increase Value $billion	A$9.3	A$2.0	A$3.7	A$5.6	A$7.4	A$9.3

The world production of cereal grains is approximately 880,000,000 Tonne[4]. Not all countries have such low average Yield as Australia. Across the world, the Yield for wheat crops varies from approximately 2T/ha to 8.7T/ha[2] where as the Yield Potential should be approximately 4T/ha. If 30% of the world's grain production has a Yield of 2T/ha, then the Yield Gap, i.e., the difference between the Yield Potential and the Actual Yield, would be 264,000,000 Tonne. This is the potential increase in the tonnage of grain that could be realised by the correct of application of Nitrogen fertilizer.

At a value of A$300/Tonne, the potential increase in crop value is A$79.2 billion. Another way of looking at this figure; this is the loss in crop value experienced by farmers around the world each year.

How can the Protein/Nitrogen/Yield Balance be used to Close the Yield Gap?

A recent trial by a farmer in Esperance, Western Australia, showed that 100litres of Flexi-N Liquid Fertilizer[(3)] increased Yield in wheat by 0.6Tonne. He also showed that the Protein also increased by 0.9% per 100L of Flexi-N added. The farmer has been using the CropScan 3000H On Combine Grain Analyser, Next Instruments, Sydney, NSW, to measure Protein in wheat on his 5 New Holland CR Series combines since 2016. The CropScan measures the grain using Near Infrared Transmission technology on a sample of grain taken off the clean grain elevator every 6-10 seconds as the grains are harvested. The Protein and Moisture data is displayed inside the cabin in the form of real-time Field Maps and tables. By combining the Protein and Yield collected off the combine, a Protein/Yield Correlation Quadrant map can be generated. This map shows four Performance Zones across the field:

Low Yield + High Protein; High Yield + High Protein
High Yield + Low Protein; Low Yield + Low Protein

The Protein/Nitrogen/Yield Balance curve shows that a Positive Yield Response can be achieved by applying more Nitrogen fertilizer in the zones where the Protein is low, i.e., the Red and Yellow zones. The Protein/Yield Correlation Quadrant map shows that approximately 87% of Mr. Hill's field was under fertilized. The Protein map shows that the Protein content in these zones ranged from 8.5 to 10.5%. The farmer's strip trials showed that he should apply between 100 and 330 litres of Flexi-N to increase the Protein and thereby increase the Yield across the field.

Based on these maps the lost Yield across this field in the 2016 harvest was:

Field size: 137.5 ha **Red Zone:** 41.5 ha **Yellow Zone:** 78.2 ha **Yield Increase in Red Zone:** 74.7 T **Yield Increase in Yellow Zone:** 70.4 T **Total Lost Yield:** 145.1 T **Lost Income @ A$300/T:** A$43,530

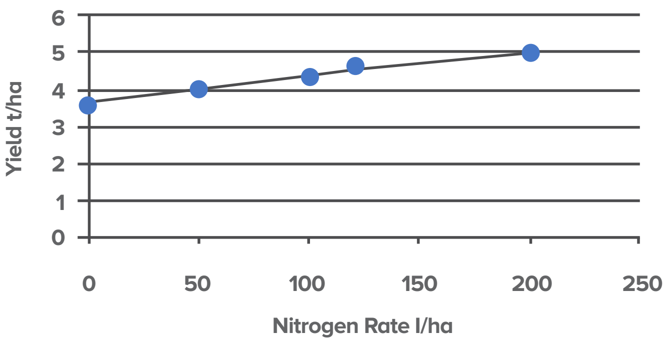
Summary:

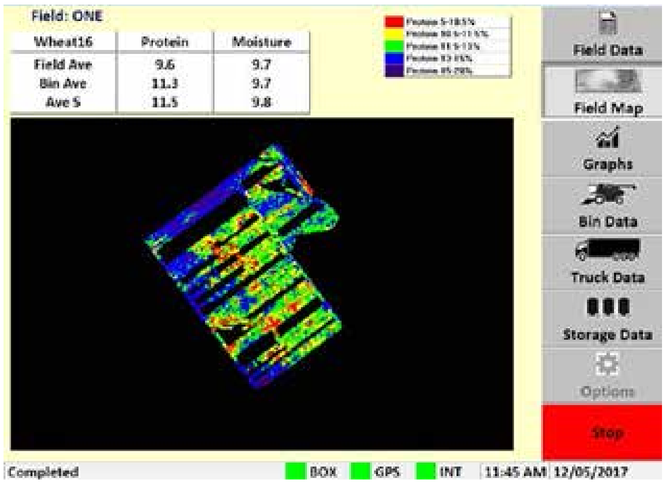
Nitrogen Availability and Uptake is the missing layer of information that can provide farmers with a simple means of increasing Yield (Quantity) and Protein(Quality)through Variable Rate Nitrogen Fertilization Applications. Measuring Nitrogen in soil and then in the crop during biomass production do not provide a reliable means of determining how much and where the Nitrogen has been used by the plant. The only direct measurement of Nitrogen Availability and Uptake is when Protein and Yield are measured in the grains during harvest. By combining Protein, Yield and GPS coordinates off a combine harvester a new analytical tool, the Protein/Yield Correlation Quadrant Map, can be generated. These maps provide a simple means of determining where and how much additional Nitrogen fertilizer will produce a Positive Yield Response. ABARES data [(6)] shows that in Australia, the average Protein content of wheat is 9.5% and the average Yield is 1.7T/ha. If all Australian wheat fields could be mapped with the Protein/Yield Correlation Quadrant Maps, then it could be possible to increase the average Yield to 3.4T/ha which would increase the Australian wheat crop by approximately 25million tonne with an increase in crop payments of $9.3 billion. If the same technology was applied across the world for wheat crops only, then the potential increase in wheat production could be 228,000,000tonne at a value of A$68.4.billion.

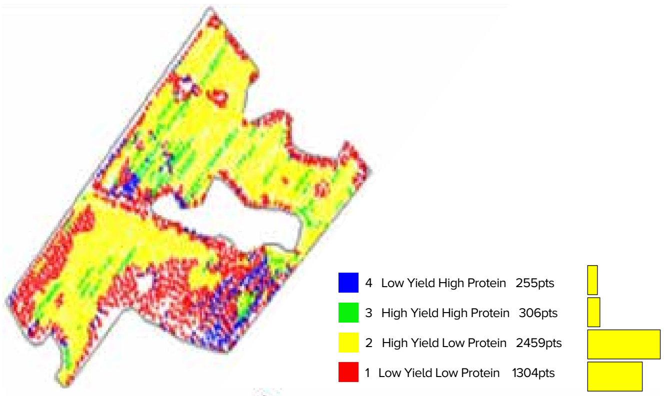
References:

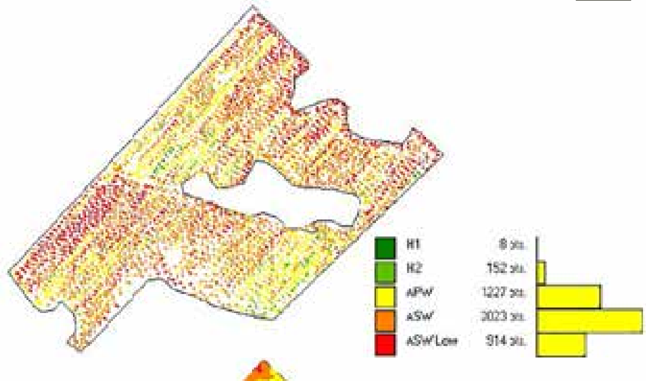
1. Comparison of grain yield and grain protein concentration of commercial wheat varieties, R Brill[1], M Gardner[2], N Fettell[3] and G McMullen[2] [1]NSW DPI Coonamble, [2]NSW DPI Tamworth, [3]University of New England and NSW DPI, Condobolin, 2012. **2.** Bridging the Yield Gap, Author: Zvi Hochman, David Gobbett, Heidi Horan, Di Prestwidge and Javier Navarro Garcia, CSIRO Ecosystem Sciences, 05 Mar 2014. **3.** How much Yield will you leave in the Field this harvest, Phillip Clancy, Milling and Grain Magazine, Perrindale Press, Feb 2020. **4.** World Agriculture Production, USDA, Foreign Agricultural Service Circular Series WAP 4-20 April 2020 **5.** US Wheat Associates, 2019 Wheat Quality Report, Arlington, VA, USA **6.** Australian Department of Agriculture, Water and Environment, ABARES.

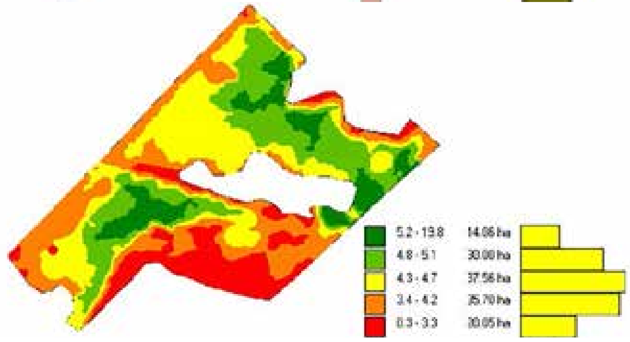
Figure 3. Yield Vs Nitrogen Application Rate











HORMONE PRODUCED IN STARVED LEAVES STIMULATES ROOTS TO TAKE UP NITROGEN

Nagoya University researchers have found that in response to the nitrogen demand of leaves, plants produce a hormone that travels from the leaves to the roots to stimulate the uptake of nitrogen from the soil. This hormone is produced in the leaves when they run short of nitrogen, and acts as a signal that regulates the demand and supply of nitrogen between the plant's shoot and the root. The findings have recently been published in the journal Nature Communications.

Nitrogen is an essential nutrient for plant growth and is very important for crop production. However, often too much nitrogen fertiliser is used, leading to contamination of the environment and rising food prices. What if plants could be made to regulate their own intake of nitrogen more effectively?

Nagoya University researchers have found the key to doing this. "By enhancing the pathway of this hormone, plants could be able to absorb nitrogen nutrients more efficiently, which may eventually minimise the use of fertilisers," says Professor Yoshikatsu Matsubayashi of the Graduate School of Science at Nagoya University.

Plant roots take up nitrogen nutrients in the form of nitrate from the soil - how much nitrogen a plant needs depends on the shoot growth stage. The larger and more numerous the leaves and stems become, the more nitrogen a plant needs.

The research team studied how plant roots sense nitrogen demand in the shoots. A previous study using a plant called Arabidopsis (better known as thale cress) had shown that certain hormones, named C-terminally encoded peptide (CEP) and CEP downstream (CEPD), respectively, modulate communications between the nitrogen-starved roots and other roots via leaves. The previous study had also revealed that plants produce other hormones that are structurally similar to CEPD.

In the new study, Professer Matsubayashi and colleagues also focused on these hormones in Arabidopsis, analysing each of their functions and thereby identifying a peptide that can strongly promote the absorption of nitrogen. The peptide, named CEP downstream-like 2 (CEPDL2), was present in leaf veins and would be produced rapidly in large amounts when the leaf ran short of nitrogen. Simultaneously, the CEPDL2 peptide would flow from shoot to roots.

In contrast, the researchers demonstrated that on plants where the CEPDL2 peptide had been destroyed, leaves were still small in the later growth period when the shoot requires a lot of nitrogen. "This means the plant cannot grow properly without this peptide, showing that the CEPDL2 peptide is the signal that regulates the balance of demand and supply between leaves and roots," Professer Matsubayashi says. "Our findings highlight one extraordinary way in which plants sense and adapt to changing conditions."

Journal Reference:

Ryosuke Ota, Yuri Ohkubo, Yasuko Yamashita, Mari Ogawa-Ohnishi, Yoshikatsu Matsubayashi. Shoot-to-root mobile CEPD-like 2 integrates shoot nitrogen status to systemically regulate nitrate uptake in Arabidopsis. Nature Communications, 2020; 11 (1) DOI: 10.1038/s41467-020-14440-8

AGRONOMY DURING 'LOCKDOWN

Pubs closed, toilet paper an aspirational item, roadblocks on state borders, social gatherings limited to two people. COVID-19 turned day-to-day life as we know it on its head - but what about life for an agronomist?

It is widely agreed that agronomists started social distancing before it had a name - long days in a vehicle mainly communicating with clients by phone. So, for many it's been business as usual; but with some subtle changes.

As would be expected, the magnitude of these changes varied a lot depending on the size and nature of the agronomy business.

Damien Erbacher runs Dawson Ag Consulting at Theodore in Central Queensland, a one-man operation. With the continuity of his business heavily dependent on his health and fitness, he took extra steps to ensure good hygiene and social distancing.

"I had a discussion with all my clients about how we communicate with minimal face to face contact and they were all pretty responsive".

"It didn't change what we did that much - a lot of communication was on the phone and if we need to catch up in the paddock, we exercised social distancing".

Larger organisations also instigated strict hygiene and distancing measures across their teams.

Ben Dawson is an agronomist with B & W Rural at Moree, NSW - a branch with 13 staff, including 6 agronomists.

B & W took the approach of minimising contact between staff and between clients.

"We split our merchandise and administration team that work out of our Moree office in two - so one team worked one week and the other team the next so if we did have an infection the whole team was not at risk".

"Our agronomists based themselves from home so there was little need for them to go into the branch at all".

On-farm, Ben said most of the work was business as usual with most communication done by phone but avoiding people travelling together in vehicles.

While everything kept functioning adequately Ben concedes the new arrangements were no replacement for face-to face contact with colleagues and clients.

"It's useful being in the office and talking to the merchandise guys and other agronomists about what's going on and a lot of decisions are made on farm around a kitchen table or in the front seat of a ute with a farmer".

Amongst the challenges have been new opportunities utilising new communication channels.

The COVID-19 crowd rules saw a rapid end to the popular breakfast meetings B & W Rural held for their clients - an opportunity to discuss what's happening around the district and new products amongst other things.

Not deterred, they started using the Zoom platform - streaming the meetings live and then having them available to watch later.

Ben was amazed with the response with over 200 farmers taking part in their meetings across several branches.

MCA Agronomist Tim Richards on a zoom conference call. Photo credit: Liesl Richards

"We had some farmers on their computer, some streaming on their phones while they were driving around. Going forward, we'll probably still stream the meetings on Zoom when we can get back to face to face as a lot of people find it convenient."

Keeping clear channels of communication functioning is a bigger challenge than most for the team at Michael Castor and Associates (MCA). Michael's team is comprised of 16 agronomists over three offices, and services clients from Belatta NSW to Dulacca QLD and therefore straddles the (closed) state border.

MCA Agronomist Tim Richards said while the restrictions imposed by the virus hampered many aspects of their operation - it had also fast-tracked some innovations in communication their team had been seeking to implement anyway.

Tim said their team was utilising the Zoom video-conferencing facility heavily for communication both within their team and with clients.

"We shut down our offices with everyone working from home so Zoom meetings replaced our normal Monday morning staff meetings around the coffee table in the office."

"On farm the aim was for less face-to-face contact with clients so we have made use of Zoom there also - allowing us to have a discussion but also screen-share spreadsheets so we're looking at the same thing."

"This technology was something we'd hoped to use more anyway, and the restrictions sped it up - made it happen."

Tim said the biggest challenge of the COVID-19 restrictions was the training of young agronomists.

"While the young agronomists are the most tech-savvy, you can't replace the time spent in the paddock, over a beat-sheet or in the front of a ute with an experienced agronomist".

So, as the restrictions are slowly lifting, the pubs are opening, and toilet paper is now freely available - are the lives of agronomists return to 'normal' also?

Certainly, the way consultants and their clients have embraced technology out of necessity during COVID-19 has clearly broken down some psychological barriers to adoption. It has also given us the opportunity to experiment and consider how it might enhance our service delivery in the future and some changes might be with us to stay.

Most agree however, that technology will never replace showing a young agronomist a rarely-seen leaf disease, a counter-meal catch-up on a wet day, a face-to-face conversation, walk through a crop or a cuppa at the kitchen table with our clients.

ENGINEERS DEVELOP PRECISION INJECTION SYSTEM FOR PLANTS

MICRONEEDLES MADE OF SILK-BASED MATERIAL CAN TARGET PLANT TISSUES FOR DELIVERY OF MICRONUTRIENTS, HORMONES, OR GENES

While the human world is reeling from one pandemic, there are several ongoing epidemics that affect crops and put global food production at risk. Oranges, olives, and bananas are already under threat in many areas due to diseases that affect plants' circulatory systems and that cannot be treated by applying pesticides.

A new method developed by engineers at MIT may offer a starting point for delivering life-saving treatments to plants ravaged by such diseases.

These diseases are difficult to detect early and to treat, given the lack of precision tools to access plant vasculature to treat pathogens and to sample biomarkers. The MIT team decided to take some of the principles involved in precision medicine for humans and adapt them to develop plant-specific biomaterials and drug-delivery devices.

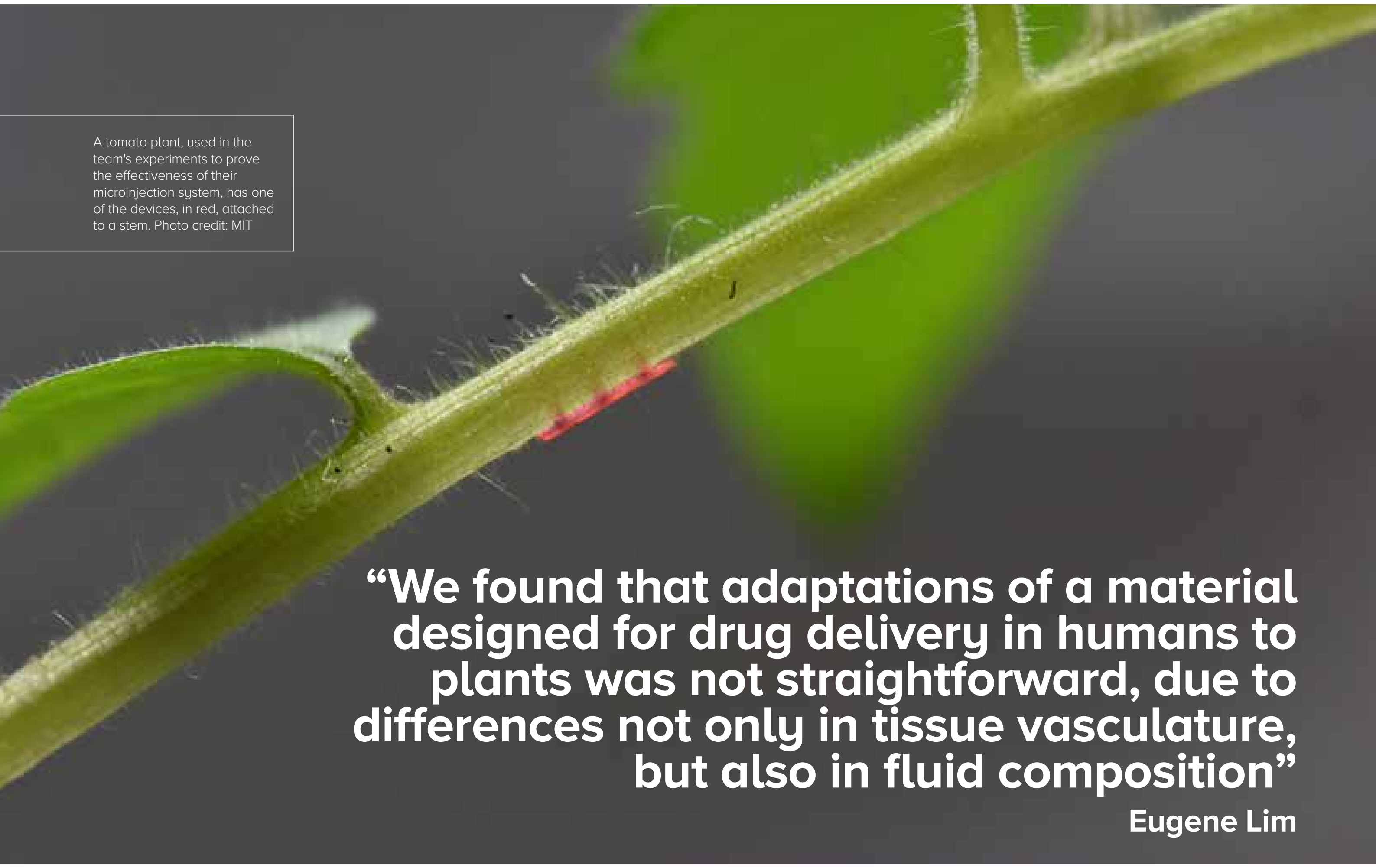
The method uses an array of microneedles made of a silk-based biomaterial to deliver nutrients, drugs, or other molecules to specific parts of the plant. The findings are described in the journal Advanced Science, in a paper by MIT professors Benedetto Marelli and Jing-Ke-Weng, graduate student Yunteng Cao, postdoc Eugene Lim at MIT, and postdoc Menglong Xu at the Whitehead Institute for Biomedical Research.

The microneedles, which the researchers call phytoinjectors, can be made in a variety of sizes and shapes, and can deliver material specifically to a plant's roots, stems, or leaves, or into its xylem (the vascular tissue involved in water transportation from roots to canopy) or phloem (the vascular tissue that circulates metabolites throughout the plant). In lab tests, the team used tomato and tobacco plants, but the system could be adapted to almost any crop, they say. The microneedles can not only deliver targeted payloads of molecules into the plant, but they can also be used to take samples from the plants for lab analysis.

The work started in response to a request from the U.S. Department of Agriculture for ideas on how to address the citrus greening crisis, which is threatening the collapse of a $9 billion industry, Marelli says. The disease is spread by an insect called the Asian citrus psyllid that carries a bacterium into the plant. There is as yet no cure for it, and millions of acres of U.S. orchards have already been devastated. In response, Marelli's lab swung into gear to develop the novel microneedle technology, led by Cao as his thesis project.

The disease infects the phloem of the whole plant, including roots, which are very difficult to reach with any conventional treatment, Marelli explains. Most pesticides are simply sprayed or painted onto a plant's leaves or stems, and little if any penetrates to the root system. Such treatments may appear to work for a short while, but then the bacteria bounce back and do their damage. What is needed is something that can target the phloem circulating through a plant's tissues, which could carry an antibacterial compound down into the roots. That's just what some version of the new microneedles could potentially accomplish, he says.

"We wanted to solve the technical problem of how you can have a precise access to the plant vasculature," Cao adds. This would allow researchers to inject pesticides, for example, that would be transported between the root system and the leaves. Present approaches use "needles that are very large and very invasive, and that results in damaging the plant," he says. To find a substitute, they built on previous work that had produced microneedles using silk-based material for injecting human vaccines.



A tomato plant, used in the team's experiments to prove the effectiveness of their microinjection system, has one of the devices, in red, attached to a stem. Photo credit: MIT

“We found that adaptations of a material designed for drug delivery in humans to plants was not straightforward, due to differences not only in tissue vasculature, but also in fluid composition”

Eugene Lim

"We found that adaptations of a material designed for drug delivery in humans to plants was not straightforward, due to differences not only in tissue vasculature, but also in fluid composition," Lim says. The microneedles designed for human use were intended to biodegrade naturally in the body's moisture, but plants have far less available water, so the material didn't dissolve and was not useful for delivering the pesticide or other macromolecules into the phloem. The researchers had to design a new material, but they decided to stick with silk as its basis. That's because of silk's strength, its inertness in plants (preventing undesirable side effects), and the fact that it degrades into tiny particles that don't risk clogging the plant's internal vasculature systems.

They used biotechnology tools to increase silk's hydrophilicity (making it attract water), while keeping the material strong enough to penetrate the plant's epidermis and degradable enough to then get out of the way.

Sure enough, they tested the material on their lab tomato and tobacco plants, and were able to observe injected materials, in this case fluorescent molecules, moving all they way through the plant, from roots to leaves.

"We think this is a new tool that can be used by plant biologists and bioengineers to better understand transport phenomena in plants," Cao says. In addition, it can be used "to deliver payloads into plants, and this can solve several problems. For example, you can think about delivering micronutrients, or you can think about delivering genes, to change the gene expression of the plant or to basically engineer a plant."

"Now, the interests of the lab for the phytoinjectors have expanded beyond antibiotic delivery to genetic engineering and point-of-care diagnostics," Lim adds.

For example, in their experiments with tobacco plants, they were able to inject an organism called Agrobacterium to alter the plant's DNA - a typical bioengineering tool, but delivered in a new and precise way.

So far, this is a lab technique using precision equipment, so in its present form it would not be useful for agricultural-scale applications, but the hope is that it can be used, for example, to bioengineer disease-resistant varieties of important crop plants. The team has also done tests using a modified toy dart gun mounted to a small drone, which was able to fire microneedles into plants in the field. Ultimately, such a process might be automated using autonomous vehicles, Marelli says, for agricultural-scale use.

Meanwhile, the team continues to work on adapting the system to the varied needs and conditions of different kinds of plants and their tissues. "There's a lot of variation among them, really," Marelli says, so you need to think about having devices that are plant-specific. For the future, our research interests will go beyond antibiotic delivery to genetic engineering and point-of-care diagnostics based on metabolite sampling."

Journal Reference:

Yunteng Cao, Eugene Lim, Menglong Xu, Jing‐Ke Weng, Benedetto Marelli. Precision Delivery of Multiscale Payloads to Tissue‐Specific Targets in Plants. Advanced Science, 2020; 1903551 DOI: 10.1002/advs.201903551

BREEDING A HARDIER, MORE NUTRITIOUS WHEAT

Some new crop varieties are bred to be more nutritious. Others are more resilient, bred to tolerate harsher environmental conditions.

In a new study, researchers report a variety of wheat that combines enhanced nutrition with increased resilience. The researchers also tested a breeding method that could reduce costs and save time compared to traditional methods.

The newly developed wheat variety contains higher levels of a naturally occurring carbohydrate, called fructans.

"Wheat with increased fructan levels can be more climate-resilient in certain situations," says Lynn Veenstra, a researcher at Cornell University. "These situations include high salinity or cold temperatures."

Fructans are long chains of the sugar fructose. Unlike the fructose present in foods, such as high-fructose corn syrup, fructans cannot be digested by humans. This makes fructans a good source of soluble fibre.

Previous research has shown that consuming foods with higher fructan levels could also promote healthy gut bacteria.

In the US, a large portion of daily fructan intake comes from wheat products, such as bread. That makes developing high-fructan wheat important.

There's yet another advantage to using high-fructan wheat. "We wouldn't have to supplement wheat products with fructans or fibre from other sources," says Veenstra. "This wheat would already contain higher levels of fructans."

But breeding high-fructan wheat can be time-consuming and expensive. "The development of nutritionally improved wheat varieties often requires extensive resources," says Veenstra.

Typically, a process called phenotyping takes the most time. Phenotyping is the measurement of crop characteristics - like fructan levels or yield.

Phenotyping allows plant breeders to compare new and existing varieties of crops. For example, they can test if newer varieties have higher or lower fructan levels than existing crops. At the same time, they need to make sure other crop features - like yield or disease resistance - haven't been reduced.

A relatively new breeding method can expedite the development of new crop varieties. Veenstra and colleagues tested variations of this method, called genomic selection.

Genomic selection uses a relatively small 'training' set of individual plants. Researchers combine phenotyping and genetic data from this training set of plants. Then they use these data to train a statistical model.

Once trained, the statistical model can predict plant characteristics - like fructan levels - based solely on genetics.

"This allows crop breeding without needing to collect data on observed characteristics," says Veenstra.

Genomic selection saves time and resources in two ways. First, the training set of plants is relatively small. That allows phenotyping to be concluded quickly. Second, genetic testing can often be much quicker than measuring crop characteristics.

Ultimately, genomic selection can allow breeders to save both cost and time during the breeding process.

There are some caveats to using genomic selection, though. Inbreeding can happen, for instance, which can reduce crop diversity. Reduced diversity can make crops susceptible to diseases.

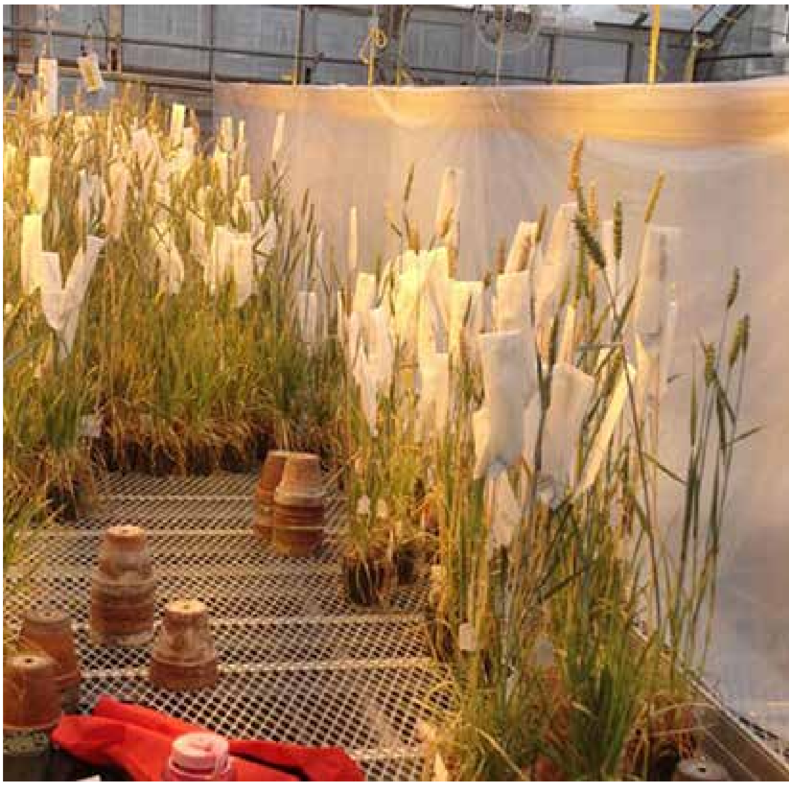
So Veenstra and her colleagues tested two different modes of genomic selection. They found that one method led to wheat with higher fructans while maintaining genomic diversity.

"I think this is the most important finding of this study," says Veenstra. "Genomic selection can be used for nutritional breeding."

Researchers still need to know more about the fructans in the new wheat variety. "We also want to determine how stable these fructans are during food processing," says Veenstra.

For example, yeast degrades different fructans at different rates. That would impact how much fructan ends up in a loaf of bread.

"I believe both wheat growers and consumers stand to benefit from high-fructan wheat," says Veenstra. "For wheat growers, high-fructan varieties have the potential to withstand climatic stress. For consumers, high-fructan wheat products may have positive impacts on gut-health."



Winter wheat crossing to produce high-fructan varieties in the greenhouse.
Photo credit: Lynn Veenstra

Journal Reference:

Lynn D. Veenstra, Jesse Poland, Jean-Luc Jannink, Mark E. Sorrells. Recurrent genomic selection for wheat grain fructans. Crop Science, 2020; DOI: 10.1002/csc2.20130

SF Greenland

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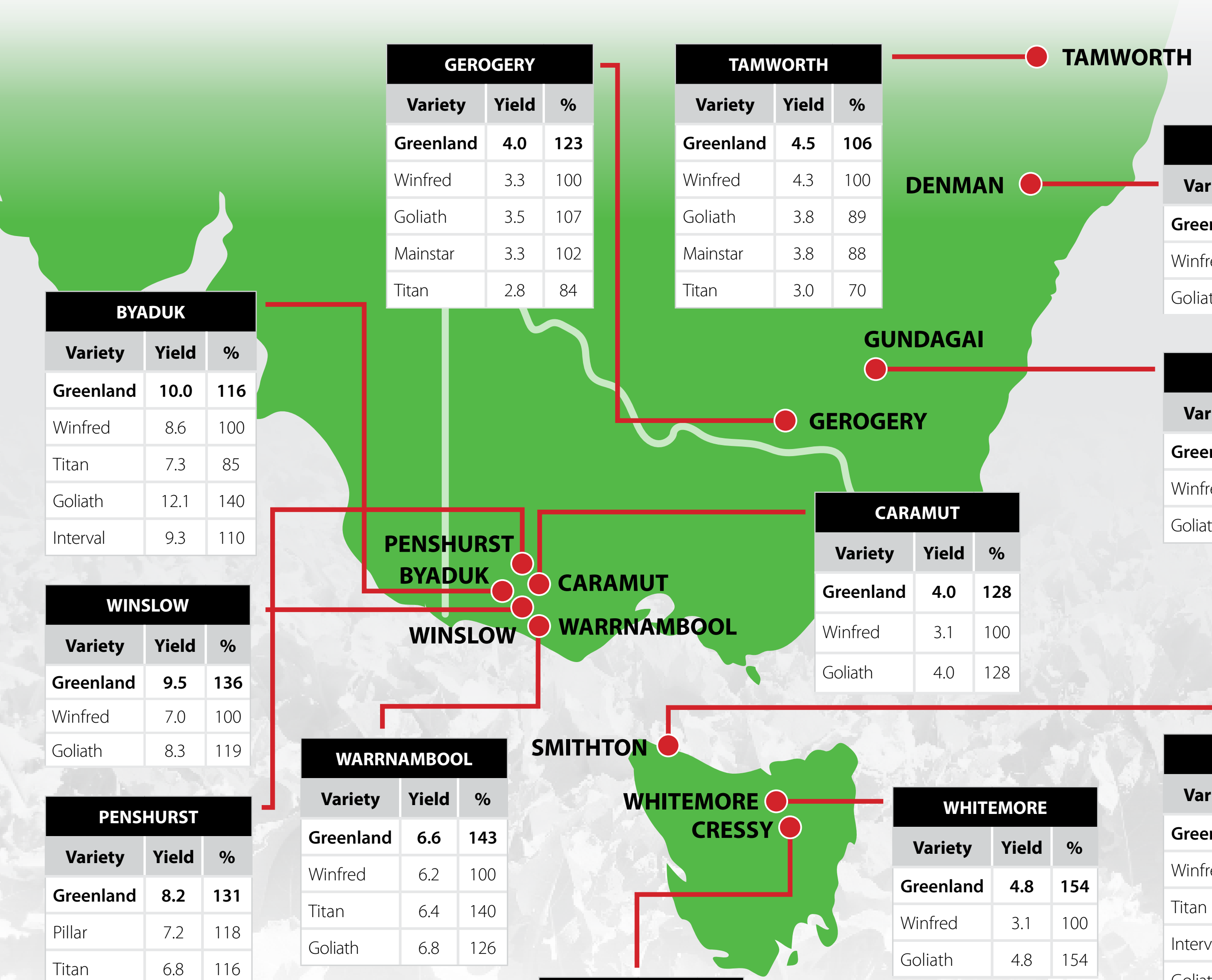
Australian livestock producers first choice.

All forage brassicas are high in quality with high ME and low NDF%. Yield is the key driver of profit for livestock grazing forage brassicas. Over 15 years, one variety continues to top yield trials - SF Greenland.

That is why it remains the No.1 choice by agronomists and serious livestock producers.



GEROGERY

Variety	Yield	%
Greenland	**4.0**	**123**
Winfred	3.3	100
Goliath	3.5	107
Mainstar	3.3	102
Titan	2.8	84

TAMWORTH

Variety	Yield	%
Greenland	**4.5**	**106**
Winfred	4.3	100
Goliath	3.8	89
Mainstar	3.8	88
Titan	3.0	70

DENMAN

Variety	Yield	%
Greenland	**14.9**	**117**
Winfred	12.7	100
Goliath	9.2	73

BYADUK

Variety	Yield	%
Greenland	**10.0**	**116**
Winfred	8.6	100
Titan	7.3	85
Goliath	12.1	140
Interval	9.3	110

GUNDAGAI

Variety	Yield	%
Greenland	**10.0**	**115**
Winfred	8.7	100
Goliath	8.6	108

CARAMUT

Variety	Yield	%
Greenland	**4.0**	**128**
Winfred	3.1	100
Goliath	4.0	128

WINSLOW

Variety	Yield	%
Greenland	**9.5**	**136**
Winfred	7.0	100
Goliath	8.3	119

WARRNAMBOOL

Variety	Yield	%
Greenland	**6.6**	**143**
Winfred	6.2	100
Titan	6.4	140
Goliath	6.8	126

SMITHTON

Variety	Yield	%
Greenland	**9.2**	**147**
Winfred	6.2	100
Titan	6.3	101
Interval	8.3	133
Goliath	8.1	129

PENSHURST

Variety	Yield	%
Greenland	**8.2**	**131**
Pillar	7.2	118
Titan	6.8	116
Winfred	6.2	100

WHITEMORE

Variety	Yield	%
Greenland	**4.8**	**154**
Winfred	3.1	100
Goliath	4.8	154

CRESSY

Variety	Yield	%
Greenland	**6.6**	**112**
Winfred	5.9	100
Goliath	6.2	105

Yield = tDM/ha
% = % control Winfred
* Gundagai - mean of 4 trials
* Penshurst - mean of 2 trails
* Warrnambool - mean of 2 trials

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CORN YIELDS FOR GRAIN OR SILAGE - WHEN BIGGER IS NOT ALWAYS BETTER

Many corn growers assume that maximising crop yield will deliver them the most profitable outcome, but Jason Scott from Pioneer® Brand Products, says this is not always the case and that the key to profitability is to understand fixed and variable costs to optimise gross margins.

Jason, who is the Corn and Microbial Lead for Pioneer said "Many farmers misunderstand the effect of yield on profit. Some think that a 10 percent increase in yield will provide a 10 percent increase in profit. This is almost never the reality, as the yield and profitability impact of increasing the value of inputs is never linear and does have a critical point at which applying additional inputs will actually cost more than they deliver".

The first step to determining maximum profitability, Jason said, is to research the market you intend to supply. "What is the financial return that market will provide? Then work the gross margin calculation back from there, setting a yield goal to meet the required revenue per hectare" he recommended.

In looking at costs, Jason recommends to identify fixed costs, as these will be the same regardless of the yield target.

"Once you know your fixed costs, the role of agronomic advice regarding planting rates, fertiliser application, water budgeting to estimate the additional cost and opportunity of increasing yield comes in to play" Jason said.

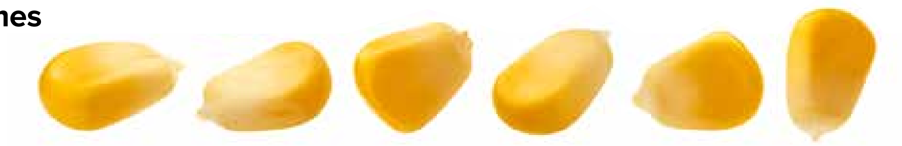
The costs of inputs such as fertiliser, water and herbicides added at critical stages could deliver 50 percent, or even 100 percent profit, but it can only go so far before yield can no longer increase, and a scenario of diminishing returns is encountered.

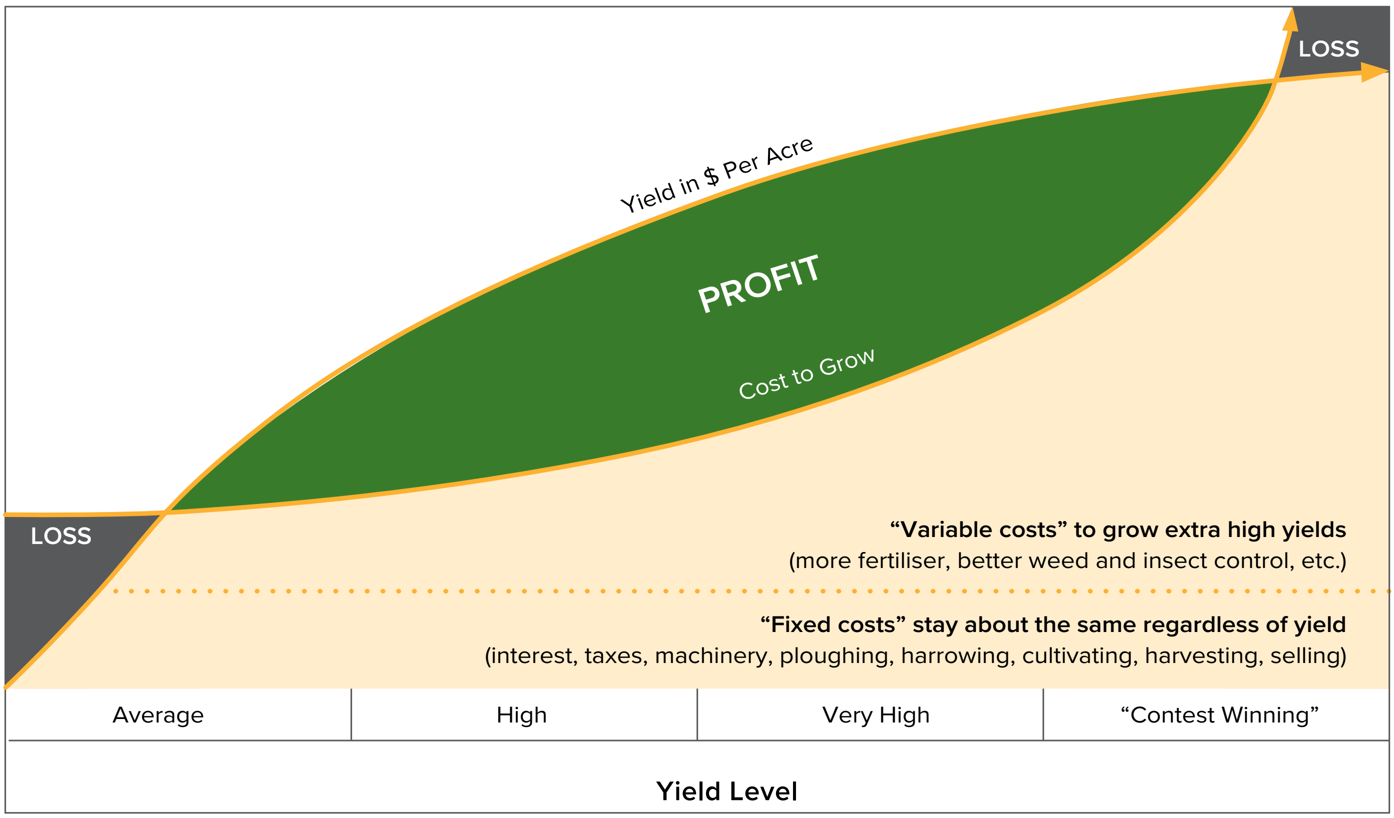
"Sure, it can be a great feeling to win a crop yield competition, but often commercial reality dictates that aiming for the biggest yield doesn't always deliver better profitability at the farm gate" Jason said.

For more information visit:
www.pioneerseeds.com.au/corn-guide to read and download Pioneer's recently updated Corn Growers Guide.

Important steps towards a profitable corn crop are:

- Determining the market you intend to supply
- Understanding the requirements of the crop
- Setting a yield goal for each field
- Planting suitable hybrids at the correct plant populations
- Providing adequate fertiliser and water at the critical growth stages
- Only growing an area you can manage effectively





The relationship between the cost of crop inputs, revenue and profitability. Source: Pioneer Corn Growers Guide www.pioneerseeds.com.au/corn-guide

RETURNING LAND TO NATURE WITH HIGH-YIELD FARMING

The expansion of farmlands to meet the growing food demand of the world's ever expanding population places a heavy burden on natural ecosystems. A new IIASA study however shows that about half the land currently needed to grow food crops could be spared if attainable crop yields were achieved globally and crops were grown where they are most productive.

The land sparing debate, which was sparked around 2005 by conservation biologists, recognised that there is usually a limit to the extent to which farmland can be made 'wildlife friendly' without compromising yields, while most threatened species only profit from the sparing or restoration of their natural habitats. Interest in this topic recently gained new momentum through the Half Earth project, which aims to return half the area of land currently being used for other purposes to natural land cover to restrict biodiversity loss and address other impacts of land use such as greenhouse gas emissions.

According to the authors of the study published in Nature Sustainability, the need for this type of strategy is urgent, given the increasing global demand for agricultural products. The study is the first to provide insight into the amount of cropland that would be required to fulfil present crop demands at high land use efficiency without exacerbating major agricultural impacts globally.

"The main questions we wanted to address were how much cropland could be spared if attainable crop yields were achieved globally and crops were grown where they are most productive. In addition, we wanted to determine what the implications would be for other factors related to the agricultural sector, including fertiliser and irrigation water requirements, greenhouse gas emissions, carbon sequestration potential, and wildlife habitat available for threatened species," explains study lead author Christian Folberth, a researcher in the IIASA Ecosystems Services and Management Program.

The study results indicate that with high nutrient inputs and reallocation of crops on present cropland, only about half the present cropland would be required to produce the same amounts of major crops. The other half could then in principle be used to restore natural habitats or other landscape elements. The findings also show that land use is currently somewhat inefficient and not primarily due to the upper limits to crop yields as determined by climate in many parts of the world, rather, it is strongly subject to management decisions.

It is difficult to say exactly how much biodiversity is impacted as a direct result of agricultural activities, but it is estimated to exceed safe boundaries, primarily due to habitat loss. In this regard, the researchers evaluated two scenarios: the first proposes maximum land sparing without constraints, except for the present cropland extent, while the second scenario puts forward targeted land sparing that abandons cropland in biodiversity hotspots and uniformly releases 20% of cropland globally. There were only marginal differences between the two scenarios in most aspects, except for wildlife habitat, which only increased significantly with targeted land sparing. This however still enabled reducing the cropland requirement by almost 40%.

Furthermore, the researchers found that greenhouse gas emissions and irrigation water requirements are likely to decrease with a reduced area of cultivated land, while global fertiliser input requirements would remain unchanged. Spared cropland could also provide space for substantial carbon sequestration in restored natural vegetation. Yet, potentially adverse local impacts of intensive farming and land sparing such as nutrient pollution or loss of income in rural areas will need to be studied further.

"The results of our study can help policymakers and the wider public to benchmark results of integrated land use scenarios. It also shows that cropland expansion is not inevitable and that there is significant potential for improving present land use efficiency. If the right policies are implemented, measures such as improved production technologies can be just as effective as demand-side measures like dietary changes," says project lead and former IIASA Ecosystems Services and Management Program Director Michael Obersteiner. "However, in all cases such a process would need to be steered by policies to avoid unwanted outcomes."

Journal Reference:

Christian Folberth, Nikolay Khabarov, Juraj Balkovi- , Rastislav Skalský, Piero Visconti, Philippe Ciais, Ivan A. Janssens, Josep Peñuelas, Michael Obersteiner. The global cropland-sparing potential of high-yield farming. Nature Sustainability, 2020; 3 (4): 281 DOI: 10.1038/s41893-020-0505-x

NANOSENSOR CAN ALERT A SMARTPHONE WHEN PLANTS ARE STRESSED

Massachusetts Institute of Technology engineers have developed a way to closely track how plants respond to stresses such as injury, infection, and light damage, using sensors made of carbon nanotubes. These sensors can be embedded in plant leaves, where they report on hydrogen peroxide signalling waves.

Plants use hydrogen peroxide to communicate within their leaves, sending out a distress signal that stimulates leaf cells to produce compounds that will help them repair damage or fend off predators such as insects. The new sensors can use these hydrogen peroxide signals to distinguish between different types of stress, as well as between different species of plants.

"Plants have a very sophisticated form of internal communication, which we can now observe for the first time. That means that in real-time, we can see a living plant's response, communicating the specific type of stress that it's experiencing," says Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering at MIT.

This kind of sensor could be used to study how plants respond to different types of stress, potentially helping agricultural scientists develop new strategies to improve crop yields. The researchers demonstrated their approach in eight different plant species, including spinach, strawberry plants, and arugula, and they believe it could work in many more.

Strano is the senior author of the study, which appears today in Nature Plants. MIT graduate student Tedrick Thomas Salim Lew is the lead author of the paper.

Embedded sensors

Over the past several years, Strano's lab has been exploring the potential for engineering "nanobionic plants" - plants that incorporate nanomaterials that give the plants new functions, such as emitting light or detecting water shortages. In the new study, he set out to incorporate sensors that would report back on the plants' health status.

Strano had previously developed carbon nanotube sensors that can detect various molecules, including hydrogen peroxide. About three years ago, Lew began working on trying to incorporate these sensors into plant leaves. Studies in Arabidopsis thaliana, often used for molecular studies of plants, had suggested that plants might use hydrogen peroxide as a signalling molecule, but its exact role was unclear.

Lew used a method called lipid exchange envelope penetration (LEEP) to incorporate the sensors into plant leaves. LEEP, which Strano's lab developed several years ago, allows for the design of nanoparticles that can penetrate plant cell membranes. As Lew was working on embedding the carbon nanotube sensors, he made a serendipitous discovery.

"I was training myself to get familiarised with the technique, and in the process of the training I accidentally inflicted a wound on the plant. Then I saw this evolution of the hydrogen peroxide signal," he says.

He saw that after a leaf was injured, hydrogen peroxide was released from the wound site and generated a wave that spread along the leaf, similar to the way that neurons transmit electrical impulses in our brains. As a plant cell releases hydrogen peroxide, it triggers calcium release within adjacent cells, which stimulates those cells to release more hydrogen peroxide.

"Like dominos successively falling, this makes a wave that can propagate much further than a hydrogen peroxide puff alone would," Strano says. "The wave itself is powered by the cells that receive and propagate it."

This flood of hydrogen peroxide stimulates plant cells to produce molecules called secondary metabolites, such as flavonoids or carotenoids, which help them to repair the damage. Some plants also produce other secondary metabolites that can be secreted to fend off predators. These metabolites are often the source of the food flavors that we desire in our edible plants, and they are only produced under stress.

A key advantage of the new sensing technique is that it can be used in many different plant species. Traditionally, plant biologists have done much of their molecular biology research in certain plants that are amenable to genetic manipulation, including Arabidopsis thaliana and tobacco plants. However, the new MIT approach is applicable to potentially any plant.

"In this study, we were able to quickly compare eight plant species, and you would not be able to do that with the old tools," Strano says.

The researchers tested strawberry plants, spinach, arugula, lettuce, watercress, and sorrel, and found that different species appear to produce different waveforms - the distinctive shape produced by mapping the concentration of hydrogen peroxide over time. They hypothesise that each plant's response is related to its ability to counteract the damage. Each species also appears to respond differently to different types of stress, including mechanical injury, infection, and heat or light damage.

"This waveform holds a lot of information for each species, and even more exciting is that the type of stress on a given plant is encoded in this waveform," Strano says. "You can look at the real time response that a plant experiences in almost any new environment."

Stress response

The near-infrared fluorescence produced by the sensors can be imaged using a small infrared camera connected to a Raspberry Pi, a $35 credit-card-sized computer similar to the computer inside a smartphone. "Very inexpensive instrumentation can be used to capture the signal," Strano says.

Applications for this technology include screening different species of plants for their ability to resist mechanical damage, light, heat, and other forms of stress, Strano says. It could also be used to study how different species respond to pathogens, such as the bacteria that cause citrus greening and the fungus that causes coffee rust.

"One of the things I'm interested in doing is understanding why some types of plants exhibit certain immunity to these pathogens and others don't," he says.

Strano and his colleagues in the Disruptive and Sustainable Technology for Agricultural Precision interdisciplinary research group at the MIT-Singapore Alliance for Research and Technology (SMART), MIT's research enterprise in Singapore, are also interested in studying is how plants respond to different growing conditions in urban farms.

One problem they hope to address is shade avoidance, which is seen in many species of plants when they are grown at high density. Such plants turn on a stress response that diverts their resources into growing taller, instead of putting energy into producing crops. This lowers the overall crop yield, so agricultural researchers are interested in engineering plants so that don't turn on that response.

"Our sensor allows us to intercept that stress signal and to understand exactly the conditions and the mechanism that are happening upstream and downstream in the plant that gives rise to the shade avoidance," Strano says.

The research was funded by the National Research Foundation of Singapore, the Singapore Agency for Science, Technology, and Research (A*STAR), and the U.S. Department of Energy Computational Science Graduate Fellowship Program.

Journal Reference:

Tedrick Thomas Salim Lew, Volodymyr B. Koman, Kevin S. Silmore, Jun Sung Seo, Pavlo Gordiichuk, Seon-Yeong Kwak, Minkyung Park, Mervin Chun-Yi Ang, Duc Thinh Khong, Michael A. Lee, Mary B. Chan-Park, Nam-Hai Chua, Michael S. Strano. Real-time detection of wound-induced H2O2 signalling waves in plants with optical nanosensors. Nature Plants, 2020; 6 (4): 404 DOI: 10.1038/s41477-020-0632-4

SCIENCE FINALLY PREVAILS WITH GM CROPPING GETTING THE GREEN LIGHT IN SA

The South Australian Parliament has finally granted the state's farmers access to GM crop innovations after passing the government's Bill to enable commercial GM crop cultivation on mainland South Australia.

Chief Executive Officer of the national peak industry organisation for the plant science sector, Mr Matthew Cossey, said, "The plant science industry is delighted that science and evidence has finally prevailed on the GM cropping issue in South Australia.

"The South Australian Government, in particular Premier Marshall and Minister Whetstone, are to be commended for their continued commitment to South Australian farmers and scientists by seeing this change through and bringing South Australia in line with other Australian mainland states.

"GM crops have been enabling farmers in other states and around the world to improve yields, reduce carbon emissions, use natural resources and pesticides more sustainably and protect the soil through no-till farming for decades. GM crops are beneficial for farmers and the environment. Now farmers on mainland South Australia will have access to this crucial agricultural technology.

"With challenging weather conditions and a changing climate only going to make farming harder, South Australian growers need access to every available safe and effective technology that can assist them to farm in a more environmentally sustainable way.

"For over 20 years, approved genetically modified crops have been grown in Australia and around the world, resulting in 183 million hectares of land being saved from full tillage cropping. This has led to improved water storage, significant reduction in soil erosion and native forests being saved from becoming agricultural production land. GM crops are responsible for savings in CO¬2 emissions of 27 billion kg - the equivalent of removing 90 per cent of passenger cars registered in Australia from the road for one year.

"South Australian farmers' access to and adoption of GM crops will assist with the challenges of drought and climate change.

"GM crops being trialed and developed - including by teams working at the Waite Campus in Adelaide - could help South Australian farmers combat environmental stresses such as drought, acidic soils, salinity and frost, and provide health benefits to consumers with products such as fortified cereals, healthier starches and oils modified to be lower in saturated fats and with improved cooking qualities.

"Opposition Leader Peter Malinauskas and Shadow Minister for Primary Industries & Regional Development, Eddie Hughes, must also be congratulated. They have modernised the South Australian Labor Party's position on GM crops and now have a policy position aligned with science. They have also shown their support for modern, sustainable farming and allowing South Australia's growers the same opportunity as their other state and international competitors.

"I also commend the leadership of Grain Producers SA who have fought this battle for their members with passion and dedication."

Mr Cossey concluded, "Farmers on mainland South Australia will now have the choice to grow whichever approved crops - including GM crops - that best suit their land and business model. We look forward to seeing South Australia embrace this agricultural technology from next season and to seeing the environment and the farming sector continue to thrive."

DIGITAL AGRICULTURE PAVES THE ROAD TO AGRICULTURAL SUSTAINABILITY

In a study published in Nature Sustainability, an ecosystem scientist and an agricultural economist outline how to develop a more sustainable land management system through data collection and stakeholder buy-in.

Bruno Basso, professor in the College of Natural Science at Michigan State University, and John Antle, professor of Applied Economics at Oregon State University, believe the path begins with digital agriculture - or, the integration of big data into crop and farmland usage.

Digital agriculture, Basso says, is where agriculture, science, policy and education intersect. Putting that data to use requires an effective balancing of competing economic and social interests while minimising trade-offs.

Technologies like genetic modification and crop production automation help produce more food than we need to survive. And while the modern food system is a monument to human ingenuity and innovation, it is not without problems.

"Agriculture's contributions to greenhouse gas emissions, water pollution and biodiversity loss show that major agricultural systems are on a largely unsustainable trajectory," Basso says. "And as the population increases, energy demands and pollution will scale accordingly."

Basso says that while policymakers, farmers and environmental groups are all speaking, they are not necessarily listening.

"There are too many barriers, too many competing interests," Basso says. "We need to bring people to the table and design a system that works for everyone - farmers, lawmakers, society and future generations."

To meet this challenge, the researchers proposed a two-step process. The initial step focuses on the design of a sustainable framework - with goals and objectives - guided and quantified by digital agriculture technologies. Implementation, the second step, involves increased public-private investment in technologies like digital agriculture, and a focus on applicable, effective policy.

This paper links advancements in agronomic sciences to the critical role policymakers must play in implementation and setting the agenda for sustainability in agriculture.

"It does no good to design a policy that the farmer will ignore," Basso says. "Policymakers must make use of digital agriculture to help drive policy. Go to the farmers and say, 'we will help you make these transitions, and we will help you transform your poorly performing and unstable field areas with financial support.'"

He recommends targeted tax incentives and subsidies to support farmers working toward a more sustainable system.

If the objective is to increase biodiversity, to reduce nitrogen fertiliser use or to grow less resource-intensive bioenergy perennials, incentivisation is key.

The researchers' analysis showed that if nitrogen fertiliser applications were based on demand and yield stability instead of uniform application, usage in the Midwest could be reduced by 36% with significant reductions in groundwater contamination and carbon dioxide emissions.

Basso says that we need to make these decisions as a society - and to brunt the cost as a society. What farmers do on their land today will affect their neighbour’s grandchildren in 30 years.

"Making use of digital agriculture is about breaking bread and creating a sustainable agricultural system. Let's bring everyone together," Basso said.

Bruno Basso, professor of earth and environmental sciences in the College of Natural Science. Photo credit: Michigan State University

Journal Reference:

Bruno Basso, John Antle. Digital agriculture to design sustainable agricultural systems. Nature Sustainability, 2020; 3 (4): 254 DOI: 10.1038/s41893-020-0510-0

GENE-EDITING PROTOCOL FOR WHITEFLY PEST OPENS DOOR TO CONTROL

Whiteflies are among the most important agricultural pests in the world, yet they have been difficult to genetically manipulate and control, in part, because of their small size. An international team of researchers has overcome this roadblock by developing a CRISPR/Cas9 gene-editing protocol that could lead to novel control methods for this devastating pest.

According to Jason Rasgon, professor of entomology and disease epidemiology, Penn State, whiteflies (Bemisia tabaci) feed on many types of crop plants, damaging them directly through feeding and indirectly by promoting the growth of fungi and by spreading viral diseases.

"We found a way to genetically modify these insects, and our technique paves the way not only for basic biological studies of this insect, but also for the development of potential genetic control strategies," he said.

The team's results appeared in The CRISPR Journal in April.

The CRISPR/Cas9 system comprises a Cas9 enzyme, which acts as a pair of 'molecular scissors' that cuts DNA at a specific location on the genome so bits of DNA can be added or removed, and a guide RNA, that directs the Cas9 to the right part of the genome.

"Gene editing by CRISPR/Cas9 is usually performed by injecting the gene-editing complex into insect embryos, but the exceedingly small size of whitefly embryos and the high mortality of injected eggs makes this technically challenging," said Rasgon.

"ReMOT Control (Receptor-Mediated Ovary Transduction of Cargo), a specific type of CRISPR/Cas9 technique developed in my lab, circumvents the need to inject embryos. Instead, you inject the gene-editing complex which is fused to a small ovary-targeting molecule called BtKV, into adult females and the BtKV guides the complex into the ovaries."

To explore the use of ReMOT Control in whiteflies, the team targeted the "white" gene, which is involved in eye color. When this gene is functioning normally, whiteflies have brown eyes, but when it is non-functional due to mutations, the insects is supposed to have white eyes.

The team found that ReMOT Control generated mutations that resulted in juvenile insects with white eyes that turned red as they developed into adults.

"Tangentially, we learned a bit about eye color development," said Rasgon. "We expected the eyes to remain white and were surprised when they turned red. Importantly, however, we found that the mutations we generated using ReMOT Control were passed on to offspring, which means that a change can be made that is inherited to future generations."

Rasgon said the team hopes its proof-of-principle study will allow scientists to investigate the same strategy using genes that affect the ability for the insects to transmit viral pathogens of crop plants to help control the insects and protect crops.

"This technique can be used for any application where you want to delete any gene in whiteflies, for basic biology studies or for the development of potential genetic control strategies," he said.

The team's CRISPR technique generated mutations that resulted in juvenile insects with white eyes that turned red as they developed into adults. These mutations were passed on to offspring, which means that a change can be made that is inherited by future generations. Photo credit: Jason Rasgon, Penn State

Journal Reference:

Chan C. Heu, Francine M. McCullough, Junbo Luan, Jason L. Rasgon. CRISPR-Cas9-Based Genome Editing in the Silverleaf Whitefly (Bemisia tabaci). The CRISPR Journal, 2020; 3 (2): 89 DOI: 10.1089/crispr.2019.0067

ELDERS INVESTS IN THE FUTURE WITH 2020 GRADUATE AGRONOMY PROGRAM

ELDERS HAS COMMENCED ITS 2020 GRADUATE AGRONOMY PROGRAM, WELCOMING CLAIRE PATTERSON, GEORGIA RODGERS, LISA GILLOGLY AND RILEY CURNOW TO THE FAMOUS PINK SHIRT FOLD.

Run by Elders' flagship research and development arm, Thomas Elder Institute (TEI), the program will provide these four promising agronomists with exposure to the industry's best practices, world-class training and a first-hand look at the support, advice and solutions Elders is renowned for providing to its clients.

Head of TEI, Dr Michael Wilkes, says the graduate program is the perfect platform for budding agronomists to identify their area of expertise and take the first steps to establishing a long and prosperous career in the industry.

"Our program takes bright and passionate young minds and provides them with opportunities to create their own pathway to success. Graduates will work alongside some the country's most experienced and respected agronomists to help nurture their passion and hone their skills."

As well as expanding their knowledge and developing technical skills, Dr Wilkes says one of the most important aspects of the program is emphasising the importance of cultivating real relationships with clients.

"Elders' reputation is founded on the connections we form with our clients. At the end of the day it doesn't matter how well you understand the technical side of the job if you don't understand the needs and circumstances of each individual client."

Further to the benefits afforded to the graduates, the program is an integral part of Elders' commitment to continually innovate and evolve.

"The program is just as important for Elders as it is for the graduates themselves. The introduction of new talent leads to the next generation of best-in-class agronomists spread throughout our network," Dr Wilkes said.

While the coronavirus pandemic has thrown much of the world's economy into a state of uncertainty, Dr Wilkes believes there has never been a better time to enter Australian agribusiness.

"Now, more than ever, the community is looking to Australian agribusiness as a beacon of light for the crucial role the sector plays in food security and the economy. Being exposed to the inner-workings of the industry during this period will be an invaluable experience that will hold our 2020 graduates in good stead as they look to establish their careers."

The program has gone from strength to strength since its introduction in 2015, as reflected by the success previous graduates have had in forging fruitful careers at Elders upon completing the program.

"You just have to look at the career paths of former graduates to appreciate the value that this program offers. Whatever goals and ambitions Claire, Georgia, Lisa and Riley have, the Elders network will support them on their journey."

GRADUATE PROFILE RILEY CURNOW

Riley Curnow joins the Elders' Graduate Agronomist Program after completing an Agricultural Science degree at the University of Adelaide. Having grown up on a mixed farm just outside of Mallala, South Australia, Riley says the seeds for a career in agriculture were planted from a very young age.

"Growing up, farming was always a massive part of my life. As I got older and became more involved in practices on the family farm, my desire to pursue a career in agriculture only grew. That's why I decided to complete year 12 and go to Uni rather than return straight to the farm," Riley said.

Riley's studies have taken him across the globe, seeing him complete a six-month exchange at the University of Guelph in Ontario, Canada, and a four-week study trip to Nottingham University in the United Kingdom. These trips exposed Riley to a variety of experiences that further fueled his passion for agriculture.

"Seeing different approaches to agronomy from around the world really opened my eyes to the vast scale of broadacre agriculture - it's where I found a genuine interest and love for agronomy away from the family farm."

Riley was drawn to the Elders Graduate Program when he came across it while completing his studies, identifying immediately that it aligned with his interests and career aspirations.

"This program provides an unbelievable opportunity to experience different aspects and regions of Australian agriculture. Being able to work alongside experts in the field is the perfect way to bridge the gap between the skills I have learnt at university and putting them into practice on-farm."

Under the guidance of respected Senior Agronomist Jason McClure at Elders' Naracoorte branch, the program is the first step in what promises to be a prosperous career in the industry for Riley, who says he can't wait to learn all that he can.

"While participating in the program I hope to absorb as much information about broadacre agriculture as possible, all the while developing positive relationships with growers and advisors."

GRADUATE PROFILE GEORGIA RODGERS

Another aspiring agronomist with a rich family history in farming is Georgia Rodgers. Hailing from the small Scenic Rim town of Beaudesert, Queensland, Georgia joins the graduate program with a Bachelor of Agriculture from Central Queensland University and a breadth of farming experience throughout her high school and university years.

Although agriculture runs deep in her family, Georgia says it wasn't until secondary school that she knew she wanted to pursue a career in the industry.

"My interest in agriculture stems from a family history of farming in the Mallee in Victoria, but I developed a genuine passion for the industry at high school where I was heavily involved in the day to day running of our school farm and an active member of the school cattle showing team."

Upon hearing about the Elders' Graduate Agronomist Program, Georgia jumped at the chance to further her knowledge and learn from "the best in the business."

"This program is incredibly valuable because it allows me to become familiar with industry processes while continuing to learn and hone my skills," Georgia said.

Having been posted at Elders Toowoomba for the first six-months of the program, Georgia has reveled in the opportunity to work with senior agronomists Matt Kenny and Ken Reimers while being exposed to a variety of sorghum, mung bean, chickpea, barley and wheat crops.

"Matt and Ken are two people with a wealth of experience - being able to work alongside them and pick their brains about anything and everything to do with an agronomy is an amazing way to find my feet in the industry."

While she may be at the start of her journey in agriculture, the graduate program promises to provide Georgia with the tools necessary to establish a long and rewarding career in the industry.

"I am looking forward to gaining the skills and knowledge I need to be able to step out with confidence and say, 'I am an agronomist'.

"I'm a firm believer in starting from the bottom, and working with the some of the most respected people in the industry is the ideal way to learn, understand and adopt the most effective and cutting-edge procedures."

PICKING UP THREADS OF COTTON GENOMICS

Come harvest time, the cotton fields look like popcorn is literally growing on plants, with fluffy white bolls bursting out of the green pods in every direction. There are 100 million families around the world whose livelihoods depend on cotton production, and the crop's annual economic impact of $500 billion worldwide underscores its value and importance in the fabric of our lives.

In the United States, cotton production centres around two varieties: 95 percent of what is grown is known as Upland cotton (Gossypium hirsutum), while the remaining 5 percent is called American Pima (G. barbadense.) These are two of the five major lineages of cotton; G. tomentosum, G. mustelinum, and G. darwinii are the others. All of these cotton lineages have genomes approximately 2.3 billion bases or Gigabases (Gb) in size, and are hybrids comprised of cotton A and cotton D genomes.

A multi-institutional team including researchers at the U.S. Department of Energy (DOE) Joint Genome Institute (JGI), a DOE Office of Science User Facility located at Lawrence Berkeley National Laboratory (Berkeley Lab) has now sequenced and assembled the genomes of these five cotton lineages. Senior authors of the paper published recently in Nature Genetics include Jane Grimwood and Jeremy Schmutz of JGI's Plant Program, both faculty investigators at the HudsonAlpha Institute for Biotechnology.

"The goal has been for all this new cotton work, and even the original cotton project was to try to bring in molecular methods of breeding into cotton," said Schmutz, who heads JGI's Plant Program. He and Grimwood were also part of the JGI team that contributed to the multinational consortium of researchers that sequenced and assembled the simplest cotton genome (G. raimondii) several years ago. Studying the cotton genomes provides breeders with insights on crop improvements at a genetic level, including why having multiple copies of their genomes (polyploidy) is so important to crops. Additionally, cotton is almost entirely made up of cellulose and it is a fibre model to understand the molecular development of cellulose.

Cotton Genomes on Phytozome

The genomes of all five cotton lineages and of cotton D are available for comparative analysis on JGI's plant data portal Phytozome, which is a community repository and resource for plant genomes. They are annotated with the JGI Plant Annotation pipeline, which provides high quality comparisons of these genomes within themselves and to other plant genomes.

"Globally, cotton is the premier natural fibre crop of the world, a major oilseed crop, and important cattle feed crop," noted David Stelly, another study co-author at Texas A&M University. "This report establishes new opportunities in multiple basic and applied scientific disciplines that relate directly and indirectly to genetic diversity, evolution, wild germplasm utilisation and increasing the efficacy with which we use natural resources for provisioning society."

The comparative analysis of the five cotton genomes identified unique genes related to fiber and seed traits in the domesticated G. barbadense and G. hirsutum species. Unique genes were also identified in the other three wild species. "We thought, 'In all of these wild tetraploids, there will be many disease resistance genes that we can make use of,'" Schmutz said. "But it turns out there isn't really that kind of diversity in the wild in cotton. And this is amazing to me for a species that was so widely distributed."

In the field, growers can easily distinguish the cotton species by traits such as flower colour, plant height, or fibre yield. To the team's surprise, even though the major cotton lineages had dispersed and diversified over a million years ago, their genomes were "remarkably" stable. "We thought we were sequencing the same genome multiple times," Schmutz recalled. "We were a little confused because they were so genetically similar."

Benefits of High Impact Science

"The results described in this Nature Genetics publication will facilitate deeper understanding of cotton biology and lead to higher yield and improved fibre while reducing input costs. Growers, the textile industry, and consumers will derive benefit from this high impact science for years to come," said Don Jones, who handles variety improvement for Cotton Incorporated, the research and marketing company representing upland cotton funded by U.S. growers of upland cotton and importers of cotton and cotton textile products, often referred to as the dirt-to-shirt value chain.

Assembling cotton's large and complex genome means being selective in choosing which team to financially support, Jones added. "We must be careful who we ask to take on these projects due to their difficulty and complexity, but we have been extremely pleased with Jeremy, Jane and their team. Many groups assemble genomes, but very few do it so well that it stands the test of time and is considered the gold standard by the world cotton community. This is one such example."

Jones noted that he talks to growers about Cotton Inc.'s long-term investment in crop research. "What I have told our growers is, 'Think of these reference genomes as a surgeon's knowledge, and of gene editing as a new tool. In order to know exactly where to use your incredibly precise tool, you have to know where to use it, which exact base or series of bases you have to alter.' Why should we invest in something that may not be an immediate benefit to us for a decade? We believe this basic research has to occur in order to drive the research. Oftentimes, these things take not five or eight years, but sometimes 10 or 15 years, because the technology develops over time."

Journal Reference:

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CROPS SOWN IN A UNIFORM SPATIAL PATTERN PRODUCE HIGHER YIELDS AND REDUCE ENVIRONMENTAL IMPACT

One of the greatest challenges facing humanity is how to grow more food while reducing the negative impacts of agriculture upon the environment. Our ability to do so requires ever-more efficient and sustainable agricultural practices. The promising news is that researchers have found out that the spatial pattern in which a farmer sows their crops is an important determinant of what they will reap.

"In the vast majority of cases, higher yields and fewer weeds are the result of sowing crops in a more uniform, grid-like pattern, where each plant is equidistant from its neighbouring plants, both within and between rows," says Professor Jacob Weiner of the University of Copenhagen's Department of Plant and Environmental Sciences.

Professor Weiner and his colleagues from Northeast Agricultural University in China conducted a large metastudy of research in the area to discover the impact of uniform spatial patterns on crop yields and weed growth. The study, now published in the serial Advances in Agronomy, demonstrated that a uniform seeding pattern resulted in higher yields in 76% of trials, and fewer weeds in 73% of trials.

In particular, the researchers looked at three of the world's most widely-cultivated crops: wheat, maize and soybean. In many studies, yields were roughly 20% higher, while one study yielded 60% more wheat and another, up to 90% more soybeans. With regards to weed growth, several studies resulted in more than a 30% reduction in weeds when traditional, less precise sowing was replaced by the uniform sowing pattern.

"Our own research has demonstrated the positive effects of the uniform sowing of wheat when weeds are present, but the new study shows that this benefit extends to other crops, both with and without competition from weeds" says Professor Weiner.

Win-win for the environment

Today, a typical seeding machine sows in a fairly precise distance between rows. However, within each row, the distance between seeds is random, meaning that some plants have close neighbours, while others have distant ones.

Conversely, when seeds are sown in uniform grid patterns, roots spread and occupy soil space faster, while more readily and efficiently absorbing nutrients. This helps to reduce the release of nutrients such as nitrogen.

"From an environmental perspective, it's win-win. There is less nitrogen runoff, and herbicide can be reduced because there are fewer weeds to contend with. This ability to increase yields and mitigate environmental impacts contributes to more sustainable agriculture," according to the the professor.

Above ground, the uniform grid pattern is advantageous because crop plants shade one another less during the early part of the growing season. One study estimated that crop leaves covered the ground several weeks sooner when sown in a uniform sowing pattern.

"It's a bit like a forest plantation, where trees are planted in a uniform pattern. In this way, there is nothing new to this principle. It just hasn't been seen as important for crops as it is for trees. People didn't believe that a sowing pattern could have such a significant impact for crops. But we were able to conclude that it does," says Jacob Weiner.

Technically, this type of precision sowing has been a challenge.

"But now, there are machines suited for the job and new ones are constantly being developed. This applies to both precision seeders and robots. You might pay more for the machine, but it's a one-time expense that pays itself off," says Jacob Weiner.

FACTS:

In the vast majority of cases, an even distribution of crops within rows results in higher yields and fewer weeds. When the distance between rows is reduced as well, even greater outcome are possible.

The study also demonstrates that uniform sowing patterns are less effective in drier areas, while more effective in wetter ones.

The study was conducted by Ping Lu and Baiwen Jiang from Northeast Agricultural University in Harbin, China and Jacob Weiner from the Department of Plant and Environmental Sciences at the University of Copenhagen.

Journal Reference:

Ping Lu, Baiwen Jiang, Jacob Weiner. Crop spatial uniformity, yield and weed suppression. Advances in Agronomy, 2020 DOI: 10.1016/bs.agron.2019.12.003

NUSEED AND BARENBRUG ENTER INTO HYBRID SORGHUM AND SUNFLOWER COLLABORATIVE AGREEMENT

Nuseed Pty Ltd ("Nuseed Australia"), a wholly-owned subsidiary of Nufarm Limited, and Barenbrug Australia Pty Ltd today announced they have entered into a formal agreement for Barenbrug Australia to license Nuseed Australia's sorghum and sunflower germplasm and conduct plant breeding, research and development and commercialisation services.

This announcement demonstrates Nuseed Australia's prioritisation and focus on its market-leading position in the Australian canola and Monola markets, and its ongoing Australian research and development commitments as the global commercialisation partner for CSIRO and GRDC for Nuseed Omega-3 canola. The collaboration aligns strongly with Barenbrug's strategic objective of continuing to invest in agriculture in Northern Australia, which includes investing in infrastructure, capability and research and development. Barenbrug have recently made significant investments in capability and infrastructure evidenced by growing their team to 106 across its Australian locations as well as investing in its new state-of-the-art facility in Toowoomba, Queensland.

Starting July 1st, 2020, all Australian-based Nuseed grain sorghum, forage sorghum and sunflower plant breeding, R&D, sales and distribution will be licensed to Barenbrug. Australian growers will have access to the same Nuseed products, sold under the Barenbrug brand. The specifics of the agreement are private.

Barenbrug's Australian Managing Director Toby Brown commented that "this agreement reinforces Barenbrug's commitment to investing in R&D in Australian agriculture. We have an extensive program focused on innovation in Australia, and we look forward to developing new products and tools for sorghum and sunflower growers. It represents an exciting next step following the recent opening of our new, state-of-the-art warehouse and seed-coating facility in Toowoomba as part of our ongoing investment in Northern Australia. Barenbrug looks forward to working with Nuseed to continue driving the breeding program forward, with the objective of providing new and existing hybrids to sorghum and sunflower growers."

Travis Rankin, Nuseed Australia's General Manager said that "Barenbrug is in a strong position to bring Australian farmers an exciting suite of next-generation hybrids from the genetics currently in the Nuseed pipeline."

Nuseed and Barenbrug are committed to a smooth transition and continued collaboration through:

- Uninterrupted supply of high-quality seed
- Maximizing Nuseed's global sorghum and sunflower germplasm to create advanced hybrids for Australian growers
- Seamless continuation of breeding activities and transition of Nuseed's summer crop plant breeding capabilities to the Barenbrug team
- Engaging with existing stakeholders from both organizations to ensure a smooth transition and service delivery

About the Nuseed sorghum and sunflower breeding program

Nuseed entered the Australian sorghum and sunflower market through the acquisition of Lefroy Seeds in 2008, followed by the purchase of HSR sorghum breeding assets and germplasm in 2013. Nuseed's summer crop breeding program has market-leading positions in sunflower and forage sorghum and has developed a strong position in grain sorghum. Globally Nuseed will continue to provide industry-leading sorghum and sunflower hybrids to other regions through global germplasm, R&D programs, sales and service in North America, South America, and Europe.

Barenbrug will continue to remain focused on being a global market leader in research anddevelopment, marketing, extension and distribution of proprietary pasture and forage seeds, cropping, turf and seed enhancement technology. In Australia, Barenbrug will continue to deliver innovations to growers and partners across a range of markets. This innovation is underpinned through a local research and development capability and supported by strong, customer focused commercial and operations teams.

About Nuseed

Nuseed delivers value beyond yield globally through dedicated service, locally proven canola, carinata, sorghum, and sunflower seed for farm customers and new plant-based solutions for end-use customers.

Nuseed develops input traits for top agronomic performance while going beyond yield to commercialize plant output traits with new value and market opportunities. Nuseed's Monola and Omega-3 Canola, Onyx Sunflowers, Wholis and BMR Sorghum, and Carinata Renewable Fuel programs are all examples of proprietary crops developed for specific end-uses and supplied by Nuseed Value Chains built through industry collaboration.

Over 250 Nuseed employees work across 11 global locations and two world-class Nuseed Innovation Centers. Established in Australia in 2006, Nuseed has grown to offer industry-leading germplasm, advanced molecular capabilities, regional R&D and commercial trials with dedicated teams in Australia, Europe, North and South America, and sales in more than 30 countries. Nuseed is a whollyowned subsidiary of Nufarm Australia Ltd. (ASX:NUF). Learn more at nuseed.com.

About Barenbrug

The Barenbrug journey began in 1904. Currently in its 116th year, it operates in 20 countries across 6 continents with over 800 dedicated employees. The Royal Barenbrug Group is the world largest, privately owned pasture, forage and turf company and its subsidiary Barenbrug Australia is one of Australia's leading seed businesses specialising in research and development, marketing, extension and distribution of proprietary pasture and forage seeds, cropping, turf and seed enhancement technology.

Since its inception, Barenbrug have always had a strong commitment to investing in new technologies, partnerships and innovation. With 22 Research and Development locations across various climates and regions Barenbrug are able to continuously develop new technologies that better enhance their offering, always with a focus on the customer and their end goals.

In Australia key products include temperate and tropical pasture varieties, fodder crops, forage cereals, field crops, turf and amenity grasses and have serviced the summer crop market in since 2007.

WILD RADISH RESEARCH REINFORCES IWM PUSH

A wild radish population in Western Australia with signs of reduced sensitivity to a popular broadleaf weed herbicide has reinforced the need to plan applications carefully and adopt integrated weed management (IWM) practices to help safeguard the future use of products.

Matt Willis, Market Development Agronomist with Bayer in WA, said the Australian Herbicide Resistance Initiative (AHRI) recently reported a shift in sensitivity to HPPD (hydroxyphenylpyruvate dioxygenase) inhibitor herbicides in a wild radish population at Wongan Hills in WA.

Palmer amaranth and waterhemp are the only two weeds worldwide with known field resistance to HPPD herbicide.

Matt said the Wongan Hills population had known resistance to Groups C, I, B and F herbicides. HPPD (Group H) herbicides had not previously been used at the site.

“The population has never had any Group H herbicides applied to it, but when treated with previously effective rates of a number of HPPD herbicides in a greenhouse pot study, there were survivors detected,” Matt told listeners in the latest episode of the company’s popular podcast, Bayer CropCast.

“However, it is important to note that the rates tested were below the recommended label rates. By the definition of the global Herbicide Resistance Action Committee (HRAC), this is not field resistance, but it is showing that sensitivities are changing, and, in this case, it was believed to be through metabolic cross resistance.”

Matt said it follows some concern over several wild radish populations in the State’s northern agricultural region, which were also were being tested.

He said the latest developments once again highlighted the importance for industry to employ strategies that could help maintain the effectiveness of existing herbicides.

“This means not using sequential applications of Group H products and, where we can, using coformulations or tank mixtures so we are not just relying on a single active (ingredient).”

“With a broadleaf herbicide like Velocity®, it contains both pyrasulfotole (Group H) and bromoxynil (Group C), so two different modes of action and, importantly, there is synergism between them. In a nutshell, one plus one equals more than two when it comes to efficacy.

“This is in addition to good application recommendations including using the maximum herbicide rate required, high water rates, targeting small weeds at the early crop stage when there is minimal shading, as well as using the appropriate nozzle set-up to ensure maximum efficacy out of these herbicides.”

Matt said growers are also encouraged to use non-chemical weed control methods where possible to help extend the effective use of existing herbicides.

“Harvest weed seed management is a big one, as well as looking at crop rotations and increased crop competition. Pasture/sheep also is an option that can help control things. Don’t just rely on herbicides.”

Fellow Market Development Agronomist with Bayer in WA and the company’s IWM lead in Australia, Craig White, agreed.

He said while the sensitivity shift in populations was complex and researchers were still investigating the cross resistance in wild radish, the message remained the same as that expressed over many years.

“Mix, rotate and do everything you can, including using every weed control option at your disposal, to keep these tools alive and viable for as long as possible,” Craig told the listeners.

He said to help growers with IWM strategies, Bayer had a dedicated website (www.crop.bayer.com.au/tools/mix-it-up) that included extensive information and resources, as well as recommendations from the global HRAC and Australian industry’s WeedSmart program.

It also includes a ‘Resistance Tracker’, which updates growers on weed resistance in their local areas. By simply entering a postcode, they can determine which weeds need to be closely monitored.

Matt Willis, Market Development Agronomist with Bayer in WA, says news of a wild radish population at Wongan Hills with reduced sensitivity to a popular broadleaf weed herbicide highlights the importance for industry to employ strategies that could help maintain the effectiveness of existing herbicides. Photo credit: Bayer

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CONTROL OF NEMATODES BY NEMATOPHAGOUS FUNGI

BY UWE STROEHER, MICROBIOLOGIST AND R&D MANAGER

NEMATODES BELONG TO ESSENTIAL SOIL ORGANISMS, MANY OF WHICH ARE BENEFICIAL IN THAT THEY CAN HELP TO CONTROL PATHOGENS AND INCREASE NUTRIENT CYCLING WITHIN THE SOIL. AS SUCH, THE MAJORITY OF NEMATODES DO NOT CAUSE ISSUES WITH PLANT HEALTH, WITH THE EXCEPTION OF PARASITIC NEMATODES. IF NUMBERS OF PARASITIC NEMATODES INCREASE, THEY WILL CAUSE SIGNIFICANT DAMAGE TO PLANT ROOTS, LEADING TO REDUCED PLANT HEALTH AND YIELD.

As most nematodes are beneficial, any analysis of nematodes in soils should distinguish between beneficial and harmful nematodes. Part of the issue with increased parasitic nematode numbers comes down to a lack of crop rotation and intensive horticultural practices, which often use large amounts of chemical fertilisers - in particular nitrogen. This is an issue which reduces the soil's natural ability to control nematodes.

Traditional nematode control has been by soil fumigation using very toxic compounds, or alternatively by methods such as solarisation. Solarisation works well, but requires the right environmental conditions. In essence, it involves cooking the soil and therefore destroying the nematodes. It is really only usable for smaller areas. The issue with using these methods to control nematode numbers is that bacteria, fungi and other soil organisms are also killed, which essentially destroys critical soil microbial activity, and also leaves the soil open for potential pathogens.

So the important question is how we control nematode pests and yet still maintain a healthy soil biota. As part of my work as the Research & Development Manager at Neutrog fertilisers, I started to look at the literature for biological nematode controls, and as it turned out, the solution was actually right under our feet.

There are a number of bacteria which parasitise nematodes, and over 300 species of fungi which kill and digest nematodes. The fungal-killing strategies are quiet diverse, from the formation of toxins to some fungi that will grow into the mouth area and digestive tract of the nematode - in essence, digesting the nematode from the inside out. Other fungi specifically target nematode eggs or female nematodes. However, the most interesting and best studied fungi are those that trap nematodes using a range of mechanisms which I'll discuss further on.


Nematode-trapping-fungi

So these fungal species are in essence 'nematophagous', meaning nematode-eating. So why do the fungi specifically target nematodes? Simply put, the fungi are looking for a source of nitrogen to cover their own requirements, and nematodes represent a meal high in protein and nitrogen.

When the level of nitrogen in the soil is boosted by high level nitrogen-containing chemical fertilisers, the fungi completely switch off their nematode trapping systems because nitrogen is now freely available in the environment, which ultimately means that the use of these types of fertilisers can inadvertently increase your nematode load.

Perhaps surprisingly, using low levels of nitrogen fertilisers in the form of urea actually induces fungi to become 'nematophagous' or nematode-eating[1]. In composted chicken litter, much of the uric acid has been converted into other forms of nitrogen-containing compounds including urea. This means that using a fertiliser based on composted chicken manure such as Neutrog's Rapid Raiser will act to switch on the fungal nematode trapping system.

So how do fungi trap nematodes? There are two main ways in which this occurs. Some fungi produce sticky pads or branches to which the nematodes get stuck to. The other way is by fungi making rings or lassoes. The nematode swims into one of these rings which triggers the ring to quickly constrict, thereby trapping the nematode *(Fig. 1)*. In both instances, once trapped, the fungi proceeds to infect via haustorial hyphae and digest the nematode.

Interestingly, fungi don't build these traps for nematodes when there is no prey - the fungi can sense molecules secreted by nematodes, and the fungi will only produce traps when nematodes are present[2]. Some fungi will even attract their nematode prey by releasing signalling molecules or fungal metabolites, which indicates to the nematode the presence of food or sexual partners[3] *(Fig. 2)*. Therefore, fungi do not simply wait for some chance encounter or build traps unnecessarily, but actively sense and attract their prey.

The question then becomes one of how we encourage these type of fungi to multiply and become part of the soil microbiota. The good things is that these trap-forming fungi are saprophytic, in that they obtain food by absorbing dissolved organic material, and as such, are not dependent on nematodes as their sole nutrient source, although in times of low nitrogen, nematodes do cover the fungal requirement of this and potentially other nutrients.

We know from various studies that nematode numbers are higher in the rhizosphere or the area around the root zone, which is perhaps not surprising considering it is the site with higher microbial biological activity compared to root free soil. However the presence of 'nematophagous' fungus does not always follow this rule - in some plants such as legumes, nematophagous fungus numbers are up to 20 times higher in the rhizosphere than in root free soils, whereas in cereal crops the numbers of trap-forming nematophagous fungi are about the same in the rhizosphere and the root free soil.

As mentioned earlier, the trap-forming fungi are saprophytic, so in essence they can and will use organic sources to cover their nutritional requirements. As such, the application of organic matter and, in particular, one that is nutrient balanced such as well-composted manure or chicken litter will help to support a diverse population of fungi capable of controlling nematodes.

In summary, a biological control solution does exist for parasitic nematodes, and for growers considering more sustainable farming practices, this is certainly a field which holds much promise.

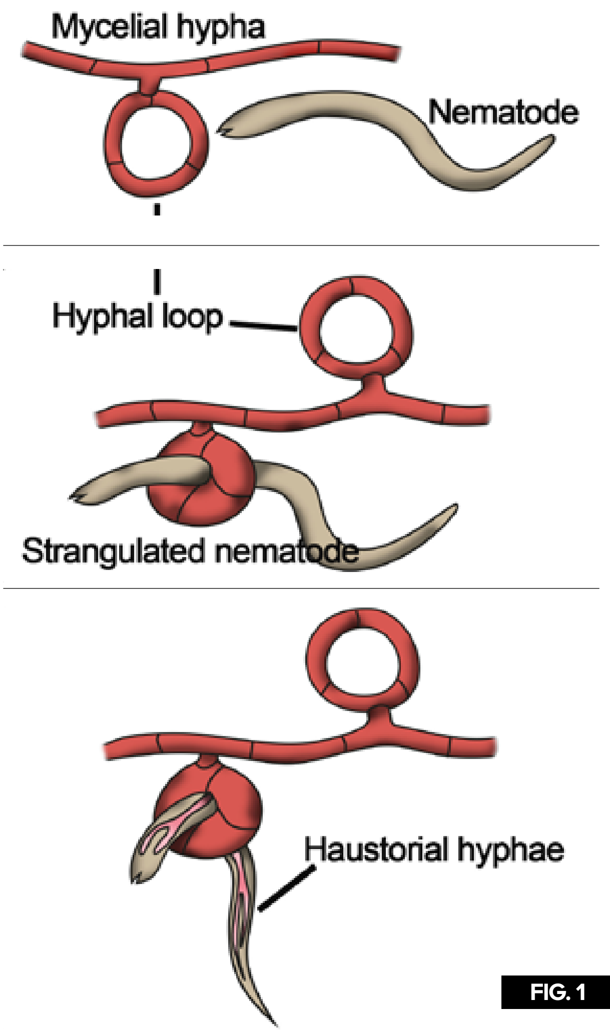

FIG. 1

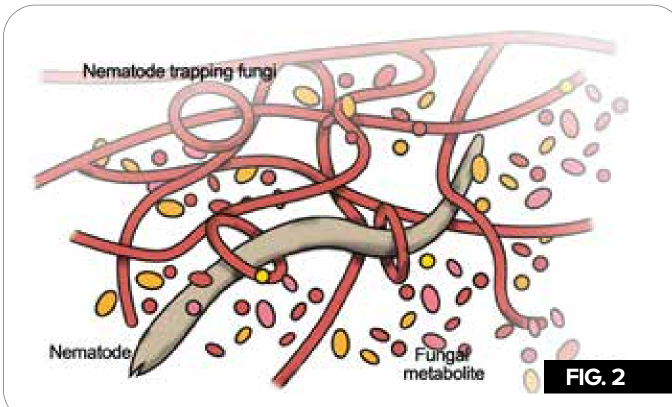

FIG. 2

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EXPERTS APPLY MICROBIOME RESEARCH TO AGRICULTURAL SCIENCE TO INCREASE CROP YIELD

The global demand and consumption of agricultural crops is increasing at a rapid pace. According to the 2019 Global Agricultural Productivity Report, global yield needs to increase at an average annual rate of 1.73 percent to sustainably produce food, feed, fibre and bioenergy for 10 billion people in 2050. In the US, however, agricultural productivity is struggling to keep pace with population growth, highlighting the importance of research into traditional practices as well as new ones.

In an effort to increase crop yield, scientists at Northern Arizona University's Pathogen and Microbiome Institute (PMI) are working with Purdue University researchers to study the bacterial and fungal communities in soil to understand how microbiomes are impacting agricultural crops. They believe technological advances in microbiome science will ultimately help farmers around the world grow more food at a lower cost.

Nicholas Bokulich, a PMI assistant research professor, and Greg Caporaso, an associate professor of biological sciences and director of PMI's Centre for Applied Microbiome Science (CAMS), have been testing a long-held farming belief that phylogenetics - the study of the evolutionary relationship between organisms - should be used to define crop rotation schedules.

The team recently published its findings regarding microbiome research in agricultural food production in Evolutionary Applications. The paper is titled, "Phylogenetic farming: Can evolutionary history predict crop rotation via the soil microbiome?"

Specifically, the traditional approach has been to rotate distantly related crops across different years to maximise plant yield. "One hypothesis for why this may be helpful is that plant pathogens are specific to a single host or to very closely related hosts. If you grow closely related crops in adjacent years, there is a higher chance that pathogens may be lying in wait for their hosts in the second year," Caporaso said. "But this hypothesis has not been directly tested."

The team's experiment, supported by a grant from the USDA National Institute of Food and Agriculture, spanned two outdoor growing seasons. In the first year, Purdue scientists Kathryn Ingerslew and Ian Kaplan grew 36 crops and agricultural weeds that differed in evolutionary divergence from the tomato. The experimental plots ranged from tomato (the same species) to eggplant (the same genus as tomato, but a different species) and sweet peppers (the same family as tomato, but in a different genus and species) through corn, wheat and rye, which are much more distant relatives of the tomato.

In the second season, the researchers only grew tomatoes on all of the plots. They found that in plots where tomatoes were grown in the first season, the year-two tomato yield was lower than in year one, as they expected. However, there were no significant reductions in tomato yield on any of the other plots. "This result suggests that while crop rotation is indeed important for yield, the effect may not extend beyond the species level," Caporaso said.

"This outcome was very surprising because the idea that closely related plants should be avoided in rotations is a widely held rule of thumb across the spectrum from small-scale gardening to large-scale agriculture," said Kaplan, a professor of entomology. "The fact that we cannot detect any signature of relatedness on crop yield - beyond the negative effects of single species monoculture (or tomato after tomato) - suggests that other factors need to be considered in designing crop rotation programs in sustainable farming systems."

Before planting in year two, Caporaso and Bokulich used microbiome sequencing methods to determine the composition of the bacterial and fungal communities in the soil. They found that a microbiome legacy of the year-one crops lived on, although both the soil bacterial and fungal communities were significantly different across the plots of different plants.

"We're now able to explore the role of microbes and the composition of microbiomes in agricultural systems in far greater depth and resolution than has ever been possible before," Caporaso said. "Those technologies can undoubtedly help us optimise agricultural systems to continuously enrich, rather than deplete, soil over time."

Caporaso says his long-term goal with this research direction is to collaborate with organic farmers who are practicing regenerative agriculture techniques. "We can learn how they can use advances in microbiome science to their advantage. I believe that this can help lower their fertiliser costs and water use, and build resiliency and food security in our communities."

Undergraduate researcher will conduct vermicomposting program to track microbiome of food waste

In a related project funded by the NAU Green Fund as well as through Caporaso's lab, which is focused on software engineering in support of microbiome research, environmental science undergraduate student researcher Christina Osterink plans to prototype a workplace composting program this summer. Her project will involve working with about 10 offices on campus to collect food scraps and deliver them to Roots Micro Farm based in downtown Flagstaff.

While diverting food waste from the landfill to an urban farm, Osterink and her team also will track the microbiome of the collected food waste through its transformation via vermicomposting, a worm-based composting method, into high-quality soil. "This will help us develop a more precise understanding of the role of microbes in the composting process as we bring together efforts from throughout NAU's campus as well as local farmers to improve NAU's sustainability and Flagstaff's soil integrity," she said.

Caporaso is hopeful findings from Osterink's research can be applied to optimise composting systems and reduce farmers' costs.

Applying microbiome research to agricultural science, a new direction for CAMS

Caporaso notes that the vermicomposting project represents a new research direction for his lab. "Most of our work at CAMS is related to human health," he said, "but there are at least as many opportunities to apply microbiome research in other areas, such as agricultural science."

Meanwhile, the next step in the crop rotation study will be to identify the important factors for plant yield, especially if evolutionary relatedness of species is ruled out.

"Do we want to rotate crops that thrive with similar soil microbiomes, so that the beneficial bacteria and fungi are already in place to support the next growing season?" Caporaso said. "That would be valuable information for both small urban farms and large industrial operations."

Journal Reference:

Ian Kaplan, Nicholas A. Bokulich, J. Gregory Caporaso, Laramy S. Enders, Wadih Ghanem, Kathryn S. Ingerslew. Phylogenetic farming: Can evolutionary history predict crop rotation via the soil microbiome? Evolutionary Applications, 2020; DOI: 10.1111/eva.12956

SCIENTISTS TAKE A STEP CLOSER TO HEAT-TOLERANT WHEAT

Researchers working on molecular-level responses in crops have taken a step closer to their goal of producing heat-tolerant wheat.

Smart thermostats tell air conditioners to switch on when the sun is bearing down in the summer and when to shut down to conserve energy. Similarly, plants have Rubisco activase, or Rca for short, that tells the plant's energy-producing enzyme (Rubisco) to kick on when the sun is shining and signals it to stop when the leaf is deprived of light to conserve energy.

Today, a team from Lancaster University reports in The Plant Journal that swapping just one molecular building block out of 380 that make up an Rca in wheat enables it to activate Rubisco faster in hotter temperatures, suggesting an opportunity to help protect crops from rising temperatures.

"We took a wheat Rca (2β) that was already pretty good at activating Rubisco in lower temperatures and swapped out just one of its amino acids with one found in another wheat Rca (1β) that works pretty well in higher temperatures but is rubbish at activating Rubisco - and the result is a new form of 2β Rca that is the best of both worlds," said Elizabete Carmo-Silva, a senior lecturer at the Lancaster Environment Centre who oversaw this work for a research project called Realizing Increased Photosynthetic Efficiency (RIPE).

RIPE is engineering crops to be more productive by improving photosynthesis, the natural process all plants use to convert sunlight into energy and yields. RIPE is supported by the Bill & Melinda Gates Foundation, the U.S. Foundation for Food and Agriculture Research (FFAR), and the U.K. Government's Department for International Development (DFID).

Here's the breakdown: naturally occurring wheat Rca 1β has an isoleucine amino acid, works up to 39 degrees Celsius, but isn't great at activating Rubisco, whereas the naturally occurring 2β has a methionine amino acid, works up to about 30 degrees Celsius, and is good at activating Rubisco. Here the team has created a new version of 2β with an isoleucine amino acid that works up to 35 degrees Celsius and is quite good at activating Rubisco.

"Essentially, 1β is a rubbish enzyme and 2β is sensitive to higher temperatures," Carmo-Silva said. "The cool thing here is that we have shown how this one amino acid swap can make Rca active at higher temperatures without really affecting its efficiency to activate Rubisco, which could help crops kickstart photosynthesis under temperature stress to churn out higher yields."

This work was carried out in vitro in E. coli, supported by a Ph.D. studentship by the Lancaster Environment Centre to first author Gustaf Degen. Importantly, these findings will support RIPE's efforts to characterise and improve the Rca of other food crops such as cowpea and soybean, each with multiple different forms of Rca.

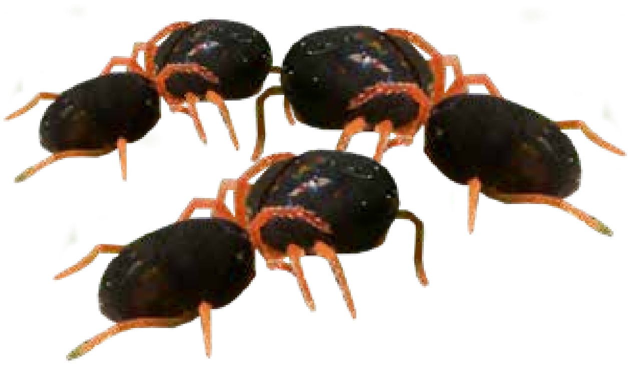
"When looking at cowpea growing regions in Africa, it goes all the way from South Africa with an average around 22 degrees Celsius to Nigeria at about 30, and areas further north get to 38," Carmo-Silva said. "If we can help Rubisco activate more efficiently across these temperatures, that is really powerful and could help us close the gap between yield potential and the reality for farmers who depend on these crops for their sustenance and livelihoods."

Journal Reference:

Gustaf E. Degen, Dawn Worrall, Elizabete Carmo-Silva. An isoleucine residue acts as a thermal and regulatory switch in wheat Rubisco activase. The Plant Journal, 2020; DOI: 10.1111/tpj.14766

MITES OF MOST CONCERN

BY NEIL JAMES, LAND MANAGEMENT EXTENSION OFFICER



Red-legged earth mites (Halotydeus destructor) are the pasture pest causing producers the most concern right now.

Plants are most susceptible as seedlings and newly sown pastures and brassicas can be severely damaged by these pests.

In older pastures, damage is visible as whitening or silvering of the leaf surface, reducing production and seed set for next year. Mites can also severely damage legumes and attack grasses and cereal crop species.

Adult mites are about 1 mm long and 0.6 mm wide. Younger mites are smaller with a black velvety body and eight red legs.

Earthmites first hatch following a combination of cool temperatures (<20°C) and adequate soil moisture (>10 mm rainfall) in the autumn from eggs laid over summer. Eggs laid by subsequent generations hatch within about a week of laying and there can be up to four generations of mites during the year.

Red-legged earth mites feed throughout the growing season and can be seen moving on the ground, or on the stalks and leaves of the plant. They are best seen while on hands and knees with a magnifying glass. A gentle rub of the ground may be necessary to get them moving.

In mid to late spring, the female mites produce summer eggs which survive in the dried bodies of the females ready to hatch the following autumn.

Registered insecticides are available for immediate control of red-legged earth mite. Consult your agronomist or advisor for treatment advice.

A long-term control strategy is to use the Australian Wool Innovation (AWI) TIMERITE® system developed by CSIRO. TIMERITE® provides the optimum spray date in spring for your property. This date is unique for each location and remains constant from year to year. Using the TIMERITE spray date will remove females before they produce their eggs, significantly reducing the number of mites hatching the following autumn.

You can obtain the ideal spraying date for your property by logging on at: **www.wool.com/land/timerite/calculatedate/** or by phoning the **AWI Helpline on 1800 070 099**

ALMOND ORCHARD RECYCLING A CLIMATE-SMART STRATEGY

Recycling trees onsite can sequester carbon, save water and increase crop yields, making it a climate-smart practice for California's irrigated almond orchards, finds a study from the University of California, Davis.

Whole orchard recycling is when old orchard trees are ground, chipped and turned back into the soil before new almond trees are planted.

The study, published in the journal PLOS ONE, suggests that whole orchard recycling can help almond orchards be more sustainable and resilient to drought while also increasing carbon storage in the soil.

"To me what was really impressive was the water piece," said corresponding author Amélie Gaudin, an associate professor of agroecology in the UC Davis Department of Plant Sciences. "Water is central to how we think about agriculture in California. This is a clear example of capitalising on soil health. Here we see some real benefits for water conservation and for growers."

BURN VS. TURN

Drought and high almond prices have encouraged higher rates of orchard turnover in recent years. The previous practice of burning trees that are no longer productive is now restricted under air quality regulations, so whole orchard recycling presents an alternative. But how sustainable and effective is it for the environment and for farmers?

For the study, scientists measured soil health and tree productivity of an almond orchard that turned previous Prunus woody biomass back into the soil through whole orchard recycling and compared it with an orchard that burned its old trees nine years prior.

They also experimentally reduced an orchard's irrigation by 20 percent to quantify its water resilience.

Their results found that, compared with burn treatments, whole orchard recycling can:

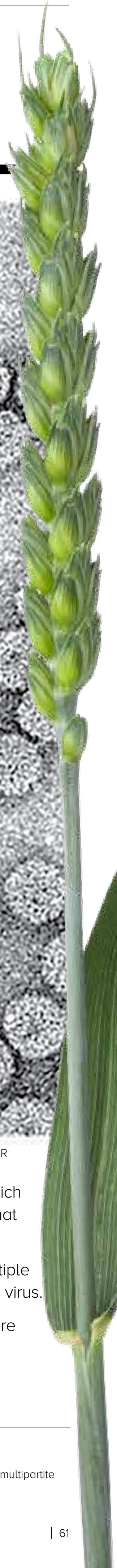
- Sequester 5 tons of carbon per hectare
- Increase water-use efficiency by 20 percent
- Increase crop yields by 19 percent

"This seems to be a practice that can mitigate climate change by building the soil's potential to be a carbon sink, while also building nutrients and water retention," said Gaudin. "That can be especially important as water becomes more limited."

Journal Reference:

Emad Jahanzad, Brent A. Holtz, Cameron A. Zuber, David Doll, Kelsey M. Brewer, Sean Hogan, Amélie C. M. Gaudin. Orchard recycling improves climate change adaptation and mitigation potential of almond production systems. PLOS ONE, 2020; 15 (3): e02295

INNOVATIVE VIRUS RESEARCH MAY SAVE WHEAT AND OTHER CROPS



University of California - Riverside scientists have solved a 20-year-old genetics puzzle that could result in ways to protect wheat, barley, and other crops from a devastating infection.

Ayala Rao, professor of plant pathology and microbiology, has been studying Brome Mosaic virus for decades. Unlike some viruses, the genetic material of this virus is divided into three particles that until now were impossible to tell apart.

"Without a more definitive picture of the differences between these particles, we couldn't fully understand how they work together to initiate an infection that destroys food crops," Rao said. "Our approach to this problem has brought an important part of this picture into very clear focus."

A paper describing the work Rao's team did to differentiate these particles was recently published in the Proceedings of the National Academy of Sciences.

Inside each of the particles is a strand of RNA, the genetic material that controls the production of proteins. The proteins perform different tasks, some of which cause stunted growth, lesions, and ultimately death of infected host plants.

Two decades ago, scientists used the average of all three particles to create a basic description of their structure. In order to differentiate them, Rao first needed to separate them, and get them into their most pure form.

Using a genetic engineering technique, Rao's team disabled the pathogenic aspects of the virus and infused the viral genes with a host plant.

"This bacterium inserts its genome into the plant's cells, similar to the way HIV inserts itself into human cells," Rao said. "We were then able to isolate the viral particles in the plants and determine their structure using electron microscopes and computer-based technology."

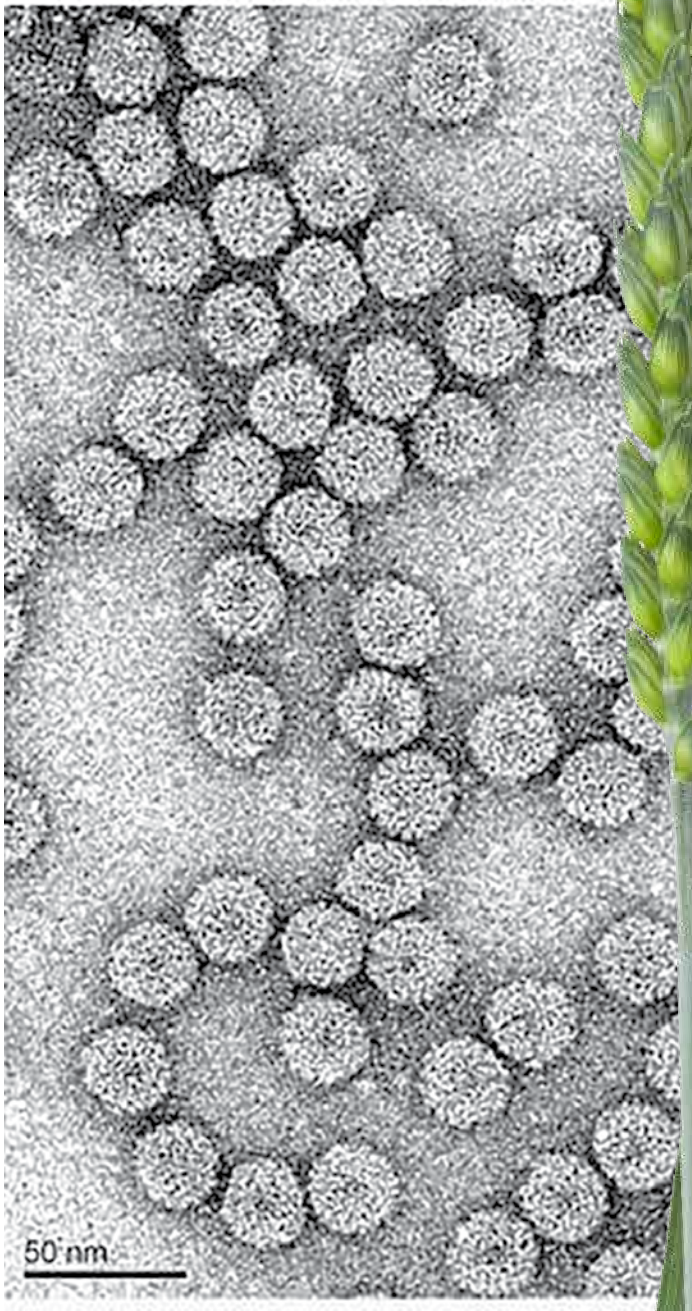
Now that one of the particles is fully mapped, it's clear the first two particles are more stable than the third.

"Once we alter the stability, we can manipulate how RNA gets released into the plants," Rao said. "We can make the third particle more stable, so it doesn't release RNA and the infection gets delayed."

This work was made possible by a grant from the University of California Multicampus Research Program and Initiatives. Professors Wiliam Gelbart and Hong Zhou of UCLA, as well as graduate students Antara Chakravarthy of UCR and Christian Beren of UCLA, made significant contributions to this project.

Moving forward, Rao is hoping to bring the other two viral particles into sharper focus with the expertise of scientists at UCLA and UC San Diego.

Brome Mosaic virus primarily affects grasses such as wheat and barley, and occasionally affects soybeans as well. According



Visually indistinguishable particles of Brome Mosaic Virus. Photo credit: Ayala Rao/UCR

to Rao, it is nearly identical to Cucumber Mosaic virus, which infects cucumbers as well as tomatoes and other crops that are important to California agriculture.

Not only could this research lead to the protection of multiple kinds of crops, it could advance the understanding of any virus.

"It is much easier to work with plant viruses because they're easier and less expensive to grow and isolate," Rao said. "But what we learn about the principles of replication are applicable to human and animal viruses too."

Journal Reference:

Christian Beren, Yanxiang Cui, Antara Chakravarty, Xue Yang, A. L. N. Rao, Charles M. Knobler, Z. Hong Zhou, William M. Gelbart. Genome organization and interaction with capsid protein in a multipartite RNA virus. Proceedings of the National Academy of Sciences, 2020; 201915078 DOI: 10.1073/pnas.1915078117

HOW A MOLECULAR 'ALARM' SYSTEM IN PLANTS PROTECTS THEM FROM PREDATORS

Some plants, like soybean, are known to possess an innate defence machinery that helps them develop resistance against insects trying to feed on them. However, exactly how these plants recognise signals from insects has been unknown until now. In a new study, scientists in Japan have uncovered the cellular pathway that helps these plants to sense danger signals and elicit a response, opening doors to a myriad of agricultural applications.

In nature, every species must be equipped with a strategy to be able to survive in response to danger. Plants, too, have innate systems that are triggered in response to a particular threat, such as insects feeding on them. For example, some plants sense "herbivore-derived danger signals" (HDS), which are specific chemicals in oral secretions of insects. This activates a cascade of events in the plant's defence machinery, which leads to the plant developing "resistance" to (or "immunity" against) the predator. But despite decades of research, exactly how plants recognise these signals has remained a bit of a mystery.

In a new study published in Communications Biology, a research team from Tokyo University of Science, Ehime University, Okayama University, The University of Tokyo, and Iwate Biotechnology Research Centre, led by Prof Gen-ichiro Arimura, attempts to shed light on exactly how plant HDS systems work. They chose to study membrane proteins called "receptor-like kinases" (RLKs), which are found in soybean leaves. They based their study on previous evidence from plants like Arabidopsis, tobacco, and cowpea, in which RLKs play a major role in HDS systems. Prof Arimura says, "Scientists have been trying to understand the molecular mechanism of plant resistance for years, but the 'sensors' involved in plant recognition of insect pests are still not known. Thus, we wanted to get a detailed understanding of these mechanisms."

To begin with, the scientists focused on soybean RLK genes that were structurally and functionally similar to a RLK gene, which is known to trigger a danger response by recognising "oligosaccharides" (small carbohydrate molecules) during pathogen attack. They speculated that owing to these similarities, soybean genes might also show a mechanism similar to that seen in pathogen resistance. They found 15 such genes through genetic analysis. Next, the scientists generated 15 types of Arabidopsis plants, each plant uniquely expressing only one of the 15 individual soy genes. When they tested these plants using oral secretions from the pest, they uncovered genes for two novel RLKs that showed a defence response specific to the oral secretions, called GmHAK1 and GmHAK2. These findings were unprecedented: the role of these RLKs in soybean HDS systems had never been revealed before. Moreover, when the scientists dug deeper into the mechanism of these regulatory factors in Arabidopsis, they found two proteins, a HAK homolog and PBL27 (which play a role in intracellular signalling), to be involved in this pathway. Accordingly, this confirmed what the scientists had initially expected - soybean and Arabidopsis possess similar mechanisms for "danger response."

In agriculture, it is crucial to develop strategies for pest control in crop plants to avoid incurring losses. This study takes a massive step in this direction by uncovering an important cellular mechanism that triggers defence response in plants. Manipulating this innate cellular system may even help scientists to fuel the development of new agricultural products, potentially making life easier for farmers.

Prof Arimura concludes, "It has been challenging to find new pest control methods that are effective and do not harm the ecosystem in any way. Our study offers a potential solution to this problem by uncovering the details of how certain plants develop resistance."

Journal Reference:

Takuya Uemura, Masakazu Hachisu, Yoshitake Desaki, Ayaka Ito, Ryosuke Hoshino, Yuka Sano, Akira Nozawa, Kadis Mujiono, Ivan Galis, Ayako Yoshida, Keiichirou Nemoto, Shigetoshi Miura, Makoto Nishiyama, Chiharu Nishiyama, Shigeomi Horito, Tatsuya Sawasaki, Gen-ichiro Arimura. Soy and Arabidopsis receptor-like kinases respond to polysaccharide signals from Spodoptera species and mediate herbivore resistance. Communications Biology, 2020; 3 (1) DOI: 10.1038/s42003-020-0959-4

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