$12.95 AUS

AUTUMN 2020 ISSUE 20

THE AUSTRALIAN AGRONOMIST MAGAZINE

How do you cultivate a healthy plant microbiome?

Reduced soil tilling helps both soils and yields

Nitrogen Fixation in Agriculture by Mutualistic and Free Living Bacteria

CORTEVA™ agriscience

TRUE PROGRESS STARTS IN THE FIELD

We bring our global presence, depth of knowledge and diverse resources so that farms and farmers flourish everywhere, moving our world forward. We are growing progress.

KEEP GROWING

CONTENTS

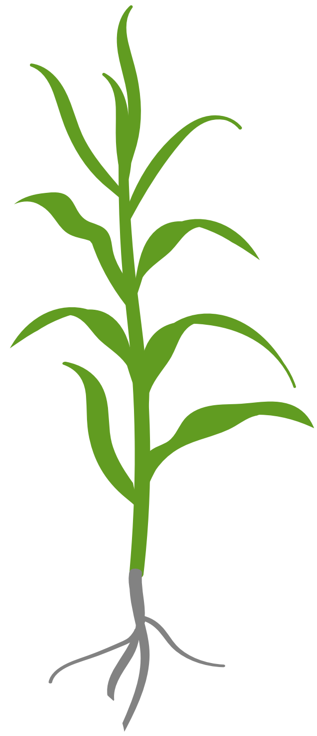
THE AUSTRALIAN AGRONOMIST

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

REDUCED SOIL TILLING HELPS BOTH SOILS AND YIELDS



AGRICULTURE DEGRADES OVER 24 MILLION ACRES OF FERTILE SOIL EVERY YEAR, RAISING CONCERNS ABOUT MEETING THE RISING GLOBAL DEMAND FOR FOOD. BUT A SIMPLE FARMING PRACTICE BORN FROM THE 1930'S DUST BOWL COULD PROVIDE A SOLUTION, ACCORDING TO NEW STANFORD RESEARCH.

The study, published in December in Environmental Research Letters, shows that Midwest farmers who reduced how much they overturned the soil - known as tilling - increased corn and soybean yields while also nurturing healthier soils and lowering production costs.

"Reduced tillage is a win-win for agriculture across the Corn Belt," said study lead author Jillian Deines, a postdoctoral scholar at Stanford's Centre on Food Security and the Environment. "Worries that it can hurt crop yields have prevented some farmers from switching practices, but we found it typically leads to increased yields."

The U.S. - the largest producer of corn and soybeans worldwide - grows a majority of these two crops in the Midwest. Farmers plucked about 367 million metric tons of corn and 108 million metric tons of soybeans from American soil this past growing season, providing key food, oil, feedstock, ethanol and export value.

Monitoring farming from space

Farmers generally till the soil prior to planting corn or soybeans - a practice known to control weeds, mix nutrients, break up compacted dirt and ultimately increase food production over the short term. However, over time this method degrades soil. A 2015 report from the Food and Agriculture Organisation of the United Nations found that in the past 40 years the world has lost a third of food-producing land to diminished soil. The demise of once fertile land poses a serious challenge for food production, especially with mounting pressures on agriculture to feed a growing global population.

In contrast, reduced tillage - also known as conservation tillage - promotes healthier soil management, reduces erosion and runoff and improves water retention and drainage. It involves leaving the previous year's crop residue (such as corn stalks) on the ground when planting the next crop, with little or no mechanical tillage. The practice is used globally on over 370 million acres, mostly in South America, Oceania and North America. However, many farmers fear the method could reduce yields and profits. Past studies of yield effects have been limited to local experiments, often at research stations, that don't fully reflect production-scale practices.

The Stanford team turned to machine learning and satellite datasets to address this knowledge gap. First, they identified areas of reduced and conventional tilling from previously published data outlining annual U.S. practices for 2005 to 2016. Using satellite-based crop yield models - which take into account variables such as climate and crop life-cycles - they also reviewed corn and soybean yields during this time. To quantify the impact of reduced tillage on crop yields, the researchers trained a computer model to compare changes in yields based on tillage practice. They also recorded elements such as soil type and weather to help determine which conditions had a larger influence on harvests.

Improved yields

The researchers calculated corn yields improved an average of 3.3 percent and soybeans by 0.74 percent across fields managed with long-term conservation tillage practices in the nine states sampled. Yields from the additional tonnage rank in the top 15 worldwide for both crops. For corn, this totals approximately 11 million additional metric tons matching the 2018 country output of South Africa, Indonesia, Russia or Nigeria. For soybeans, the added 800,000 metric tons ranks in between Indonesia and South Africa's country totals.

Some areas experienced up to an 8.1 percent increase for corn and 5.8 percent for soybeans. In other fields, negative yields of 1.3 percent for corn and 4.7 for soybeans occurred. Water within the soil and seasonal temperatures were the most influential factors in yield differences, especially in drier, warmer regions. Wet conditions were also found favourable to crops except during the early season where water-logged soils benefit from conventional tillage that in turn dries and aerates.

"Figuring out when and where reduced tillage works best could help maximise the benefits of the technology and guide farmers into the future," said study senior author David Lobell, a professor of Earth system science in the School of Earth, Energy & Environmental Sciences and the Gloria and Richard Kushel Director of the Centre on Food Security and the Environment.

It takes time to see the benefits from reduced tillage, as it works best under continuous implementation. According to the researchers' calculations, corn farmers won't see the full benefits for the first 11 years, and soybeans take twice as long for full yields to materialise. However, the approach also results in lower costs due to reduced need for labor, fuel and farming equipment while also sustaining fertile lands for continuous food production. The study does show a small positive gain even during the first year of implementation, with higher gains accruing over time as soil health improves. According to a 2017 Agricultural Censuses report, farmers appear to be getting on board with the long-term investment and close to 35 percent of cropland in the U.S. is now managed with reduced tillage.

"One of the big challenges in agriculture is achieving the best crop yields today without comprising future production. This research demonstrates that reduced tillage can be a solution for long-term crop productivity," Deines said.

Journal Reference:

Jillian M Deines, Sherrie Wang, David B Lobell. Satellites reveal a small positive yield effect from conservation tillage across the US Corn Belt. Environmental Research Letters, 2019; 14 (12): 124038 DOI: 10.1088/1748-9326/ab503b

“One of the big challenges in agriculture is achieving the best crop yields today without comprising future production. This research demonstrates that reduced tillage can be a solution for long-term crop productivity”

Jillian Deines

TRASHED FARMLAND COULD BE A CONSERVATION TREASURE

Low-productivity agricultural land could be transformed into millions of hectares of conservation reserve across the world, according to University of Queensland-led research.

The research team proposed a new way of understanding the conservation value of "uncontested lands" - areas where agricultural productivity is low.

Dr Zunyi Xie, from UQ's School of Earth and Environmental Sciences, said uncontested lands could be low-hanging fruit for expanding the world's conservation areas.

"These spaces could offer great opportunities, and it's time we recognise what that could mean and where it might be," Dr Xie said.

"Global agricultural area has actually declined over the past two decades due to socio-political trends, market changes and environmental degradation.

"Restoring degraded lands that are no longer contested for agricultural use, due to low productivity or inappropriate farming practices, may present a major conservation opportunity if balanced with local community and indigenous groups' needs."

UQ's Associate Professor Eve McDonald-Madden said this approach could be cheaper and quicker than others.

"Quite rightly, most conservation endeavours focus on protecting the best places for biodiversity," she said.

"Yet these areas are often in high demand for other uses, such as agricultural production or resource extraction.

"The contested nature of these places makes land acquisition for protecting species expensive and a lengthy process.

"While those battles for high-value biodiversity areas continue, as they should, let's take advantage of the vast areas of underutilised agricultural land across the globe.

"Those areas that don't play a key role in food security or economic well-being and once revived can bring conservation gains."

The team has been working on mapping and quantifying opportunities for protecting these lands, believing they could help nations reach their United Nations Sustainable Development Goals (SDGs) commitments.

"This research will support effective prioritisation of conservation restoration to support biodiversity and in an attempt to tackle climate change," Dr Xie said.

"It also provides a critical evidence base, helping broaden the options available to those making decisions about what land to preserve by highlighting areas that may otherwise be overlooked.

Journal Reference:

Zunyi Xie, Edward T. Game, Richard J. Hobbs, David J. Pannell, Stuart R. Phinn, Eve McDonald-Madden. Conservation opportunities on uncontested lands. Nature Sustainability, 2019; DOI: 10.1038/s41893-019-0433-9

AS A WAY TO FIGHT CLIMATE CHANGE, NOT ALL SOILS ARE CREATED EQUAL

Recognising diversity of soil organic matter can help science and agriculture move forward with carbon sequestration

As the planet warms due to excess carbon dioxide in the atmosphere, a solution for drawing down that carbon - or at least a major part of it - lies silently below us.

Soil organic matter - made of decomposing plant, animal and microbial tissue - is what distinguishes healthy, vibrant soil from just plain dirt. Making up about 3% of productive agricultural soils, soil organic matter is an effective "carbon sink" that can store, in the ground, the carbon dioxide plants pull from the atmosphere. Along with reducing fossil fuel emissions, employing soils as vast carbon sinks is considered a key strategy in combating climate change.

Accruing soil organic matter effectively and sustainably requires a deeper understanding of its formation, persistence and function. And according to Colorado State University scientists, not all soil organic matter is created equal.

A set of studies led by CSU soil scientist Francesca Cotrufo offers a newly nuanced understanding of different soil organic matter components that can be increased through varied management strategies. Publishing in Global Change Biology, Cotrufo and co-authors Jocelyn Lavallee and Jennifer Soong establish a framework for classifying soil organic matter into two broad categories that are fundamentally different in origin and makeup. In a related study in Nature Geoscience, Cotrufo led an experimental and statistical survey of these soil organic matter components across European forests and grasslands.

Only by recognising the diversity of soil organic matter can science, government and agriculture move forward with carbon sequestration to help reverse the tide of climate change while increasing the health of our soils, the scientists say.

"Because of thousands of years of historical land use and conventional agriculture, we have contributed to consuming soil organic matter and emitting carbon from the soil into the atmosphere," says Cotrufo, a professor in the Department of Soil and Crop Sciences and senior scientist in the Natural Resource Ecology Laboratory. "Now, we have the opportunity to put it back."

That opportunity, Cotrufo and colleagues say, comes with thinking of soil organic matter as having two major components.

The first is called "particulate organic matter," made up of lightweight, partly decomposed plants and fungi residues that are short-lived and not well protected.

The second is "mineral-associated organic matter," largely made of byproducts of the decomposition of microbes that chemically bind to minerals in the soil. This type of matter is more resilient and able to persist in the ground for centuries.

Insights around the formation of these different classes of soil sprouted from previous work Cotrufo published in 2013, establishing a "microbial-efficiency mineral-stabilisation framework" that transformed the way scientists understand how organic matter persists in soils. Cotrufo and colleagues proposed that microbial decomposition of plant matter can act as a stabiliser for soil organic matter; it was previously thought that preserving carbon in soil would require halting decomposition.

Cotrufo calls particulate organic matter the "checking account" of soils. It turns over continuously and supports nutrient cycling but requires regular deposits to stay vital. Mineral-associated organic matter, then, is the "savings account": it gets a smaller fraction of deposits but is inherently more stable.

Conventional agriculture, Cotrufo says, has caused us to exhaust our checking account and start living off our savings. This happens because of farms selecting few crops with minimal root production, harvesting much of the above-ground biomass, and maintaining few and chemically homogenous plant inputs into the soils.

By taking cues from nature and understanding how natural prairies and forests manage their soil checking and savings accounts, more forward-thinking strategies are possible for upending farming and land use to be more sustainable, Cotrufo says. To regenerate healthy soil that can capture excess carbon, both types of soil pools must be augmented, she adds.

Writing in Nature Geoscience, the researchers showed that European grasslands and forests with symbiotic partnerships between fungi and plants store more soil carbon in nitrogen-demanding mineral-associated organic matter. But forests that depend on symbiosis with other fungal species store more carbon in particulate organic matter, which is more vulnerable to disturbance, but has a lower nitrogen demand and can accumulate carbon indefinitely.

Cotrufo will continue researching how particulate and mineral-associated soil organic matter are distributed, with plans to incorporate U.S. land surveys into her datasets. Cotrufo was also recently named the Nutrien Distinguished Scholar of Agricultural Sciences at CSU, a one-year award of $12,000 reserved for distinguished faculty who are making significant impacts in their fields.

Cotrufo recently gave a talk on soil as "humanity's capital" at The Land Institute, where she provided insight into her early stake in soil science, and how the field has evolved over her career.

Journal Reference:

M. Francesca Cotrufo, Maria Giovanna Ranalli, Michelle L. Haddix, Johan Six, Emanuele Lugato. Soil carbon storage informed by particulate and mineral-associated organic matter. Nature Geoscience, 2019; 12 (12): 989 DOI: 10.1038/s41561-019-0484-6

HYTTEC® YOUR NEW BREED OF TT

HyTTec combines hybrid seed traits, including early vigour, a strengthened disease background, and excellent yield performance, with the herbicide tolerance benefits of the TT system.

We understand why some growers might be hesitant to try a hybrid so we're taking a different approach to traditional canola hybrids. We're offering our HyTTec seed for less upfront plus an End Point Royalty (EPR) to help growers tackle one of the biggest hurdles.

If your growers have already tried a TT hybrid, or if they are an OP grower looking to upgrade, go with the breeder who has a vested interest in their success.

HyTTec delivers:

- Hybrid advantages of early vigour and yield
- All the existing herbicide tolerance benefits of TT varieties for the same reliable weed control
- A new option for cropping programs
- The confidence of growing seed from the TT specialists, with a lower upfront cost

Speak to your agronomist or Nuseed representative today.

* An EPR (End Point Royalty) of $10 per tonne (ex GST) applies to HyTTec Trophy and HyTTec Trident.
Disclaimer: Nuseed and its agents shall not be liable for any direct nor consequential loss, except for liability that cannot be excluded by statute. HyTTec is a registered trademark of Nuseed Pty Ltd.

HYTTEC® TROPHY HYBRID CANOLA

YOUR MID-SEASON TT CHAMP

HyTTec® Trophy is the first release of a new breed of hybrid TT Canola from Nuseed, your TT specialists.

If you're looking for a proven performer, HyTTec Trophy has form in the field.

- Top of the table **yield performance** for superior returns
- Strong **early vigour** driving better establishment and resilience
- **Highly adaptable** to a range of growing environments
- **Strong blackleg resistance** of R-MR for extra security
- Available under an **End Point Royalty*** to reduce your upfront cost

END POINT ROYALTIES
EPR
REDUCE YOUR UPFRONT COST

HYTTEC® TRIDENT

YOUR NEXT BIG HYBRID TT PARTNER

The yield gap just got bigger - **HyTTec® Trident** is your high performing early maturing canola.

- **HyTTec Trident** significantly **outperforms similar varieties** across a range of yield environments
- Especially strong in growing environments suited to **early maturing** canola
- The ideal combination of early **get-up-and-go** and herbicide tolerance for superior paddock clean-up
- Premium disease package, **rated R for Blackleg** resistance
- Available under an **End Point Royalty*** to reduce your upfront cost

END POINT ROYALTIES
EPR
REDUCE YOUR UPFRONT COST

SPEAK TO YOUR LOCAL RESELLER TODAY
LIMITED STOCK

nuseed®

@NuseedAustralia nuseed.com.au

HOW DO YOU CULTIVATE A HEALTHY PLANT MICROBIOME?

SCIENTISTS ARE HOMING IN ON WHAT A HEALTHY HUMAN MICROBIOME LOOKS LIKE, MAPPING THE NORMAL BACTERIA THAT LIVE IN AND ON THE HEALTHY HUMAN BODY. BUT WHAT ABOUT A HEALTHY PLANT MICROBIOME?

Is there even such a thing as a healthy plant microbiome in today's agricultural fields, with acres of identical plants assaulted by pesticides and herbicides and hyped up on fertiliser?

A new study by University of California, Berkeley, microbial ecologists used experimental evolution to help identify the core microbiome of commercial tomatoes. They selected for those microbial taxa that best survived on the plants and then showed that these "domesticated" microbial communities are able to effectively fend off random microbes that land on the plants. In other words, these selected communities look like a stable, healthy plant microbiome, akin to what a robust tomato plant might pass to its offspring.

The results are good news for growers who hope that manipulating the plant microbiome, perhaps with probiotics, will make for healthier fields that need less fertiliser and less or no pesticides to produce good yields.

"I see the implications of this work not just being about probiotics, but also about guiding agricultural practice," said study leader Britt Koskella, a UC Berkeley assistant professor of integrative biology. "When planting fields, we should be thinking about how what we do - whether it is age structuring of crops or monocropping versus crop rotations, what is in the soil or what is living nearby - can impact the acquisition and health of the plant microbiome. We should be manipulating the growing conditions in a way that microbial transmission is more akin to what would happen naturally."

Koskella, lead author Norma Morella, who is now a postdoctoral fellow at the Fred Hutchinson Cancer Research Centre in Seattle, and their colleagues reported their findings online recently in the journal Proceedings of the National Academy of Sciences (PNAS).

How do seedlings get microbiomes from their mothers?

Koskella studies the microbial ecology of plants and how it affects plant health, much like biologists study the human microbiome's role in health. Focusing on agricultural crops, she has some of the same concerns as biologists who worry about the transmission of a healthy human microbiome - skin, gut and more - from mother to baby.

When seedlings are first put into fields, for example, there are often no nearby adult plants from which they can acquire leaf and stem microbes. In the absence of maternal transmission, Koskella wondered, how do these plants acquire their microbiomes, and are these microbiomes ideal for the growing plants?

And, if the microbiomes are not well adapted - for example, not resistant to disease-carrying microbes - can they be improved?

These questions are becoming increasingly important as growers and industry alike try to improve crop yield and sustainability by surrounding seeds with desirable microbes, engineering soil microbial communities or spraying desired microbes on growing plants.

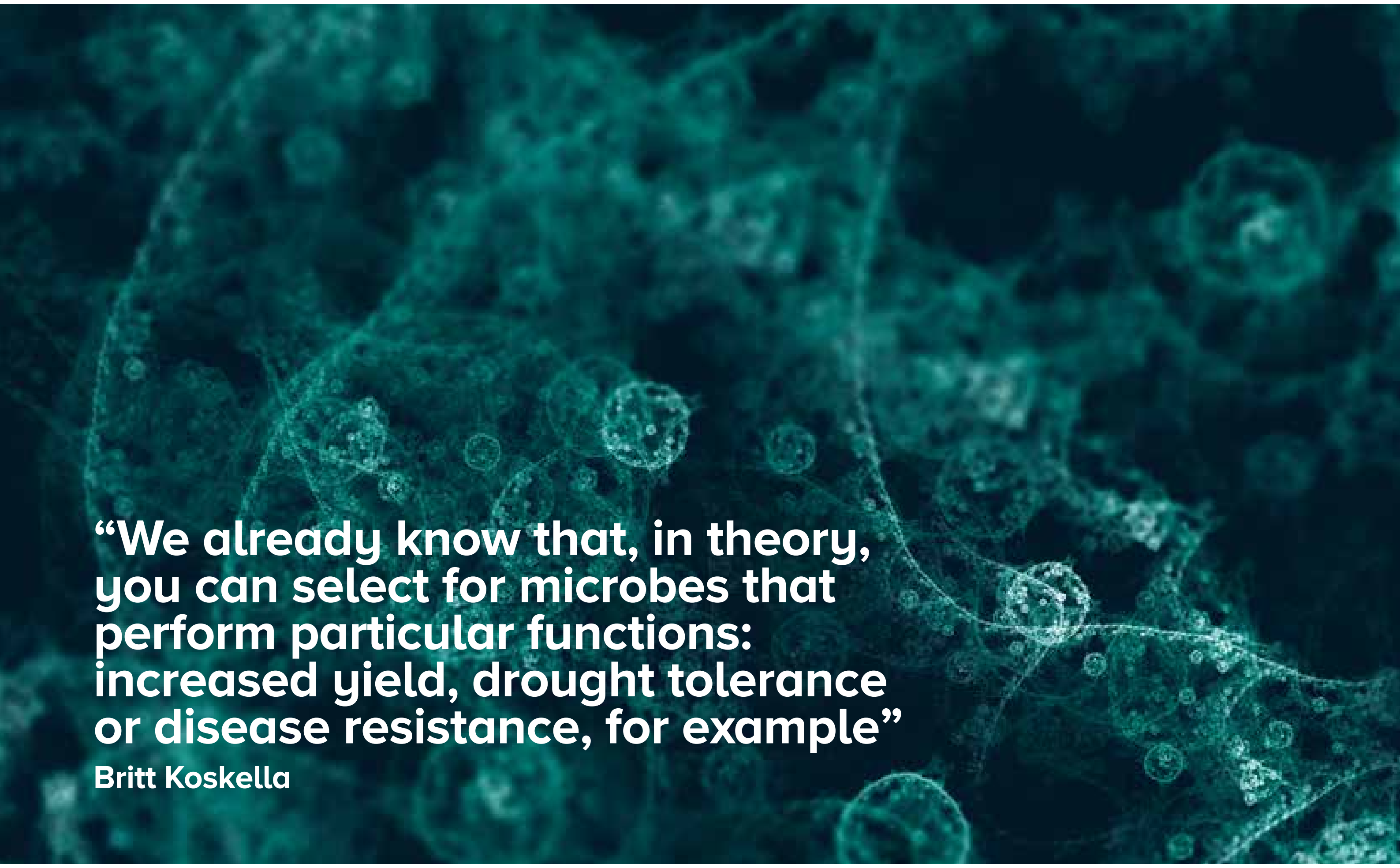
Increasing evidence also shows that microbiomes can affect yield, tolerance to drought and even the flowering time of plants. Can microbiomes be enhanced to achieve this, and will enhanced microbiomes survive long enough to help the plants?

The new study is encouraging.

"We already know that, in theory, you can select for microbes that perform particular functions: increased yield, drought tolerance or disease resistance, for example," Koskella said. "We are showing here that you can, in principle, create a microbial community that has the function you are interested in, but also is uninvadable, because it is really well-adapted to that plant."

Cultivating a core microbiome

The researchers' experiments, conducted in greenhouses on UC Berkeley's Oxford Tract, involved taking five types of tomatoes



"We already know that, in theory, you can select for microbes that perform particular functions: increased yield, drought tolerance or disease resistance, for example"
Britt Koskella

and spraying four successive generations of plants with the microbiomes of the previous generation. The first generation was sprayed with a broad mix of microbes found on a variety of tomatoes in an outdoor field at UC Davis.

Nurturing the microbial community of each type of tomato through successive generations allowed it to adapt to each strain, ideally weeding out the maladapted microbes and allowing the well-adapted ones to flourish.

By sequencing the 16S ribosomal subunits of the tomatoes' microbial communities after each generation - a technique that allows identification of different bacterial taxa - they were able to show that, by the fourth generation, only 25% of the original microbial taxa remained.

"So, 75 percent of the original bacteria that we spray on go virtually extinct during the experiment," Koskella said. "That is really interesting in itself, because it suggests that a lot of the microbes out there aren't well adapted, they are kind of there by chance. The wind blew them there, rain splashed them there, but they are not thriving, they are likely not adapted to that particular environment."

The remaining 25%, which were very similar across all independent selection lines and across the five tomato strains, looked very much like a "core" microbiome: the key microbes necessary for a healthy plant.

When Morella sprayed tomato plants with a microbial mixture - half from the partially adapted microbiome of the first generation, half from the more mature fourth generation microbiome - the fourth generation microbes took over, suggesting that they were much better adapted to the tomato.

"I think this work on the tomato supports the idea that leaf bacteria are probably very distinctive and have traits that are required for them to grow well on those plants, and that just the fact that you can find things there may mean that they are there only transiently and probably in the process of dying," said co-author Steven Lindow, a UC Berkeley professor of plant and microbial biology who has been investigating plant-pathogen interactions for nearly 50 years.

"This is very consistent with what we had found before, that good plant colonists can grow on many plants and, in so doing, usurp the ability of anybody else to also grow there. The prophylactic effect is definitely very strong and real and very important in keeping other plant colonists away."

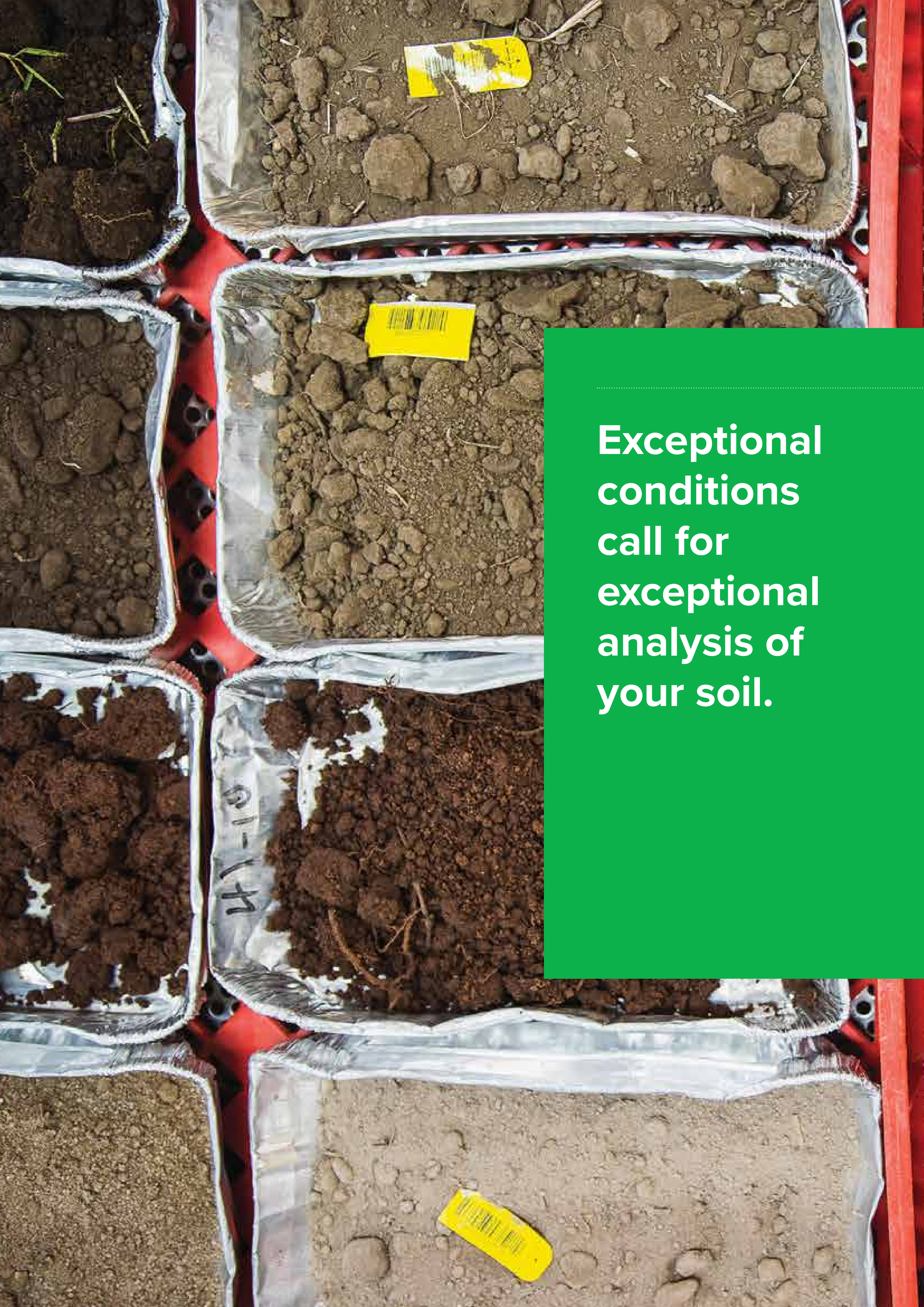
"What you want to ask, really, is, 'Who wins when you put them head to head? The selected microbiome or the unselected microbiome?'" Koskella said. "That, to me, is my favourite part of the whole experiment and was the 'aha! moment': Selection works, you really can select for a microbiome that it is well adapted and not invadable, at least under the conditions we used for selection."

Koskella's group is now running further experiments to determine whether the selected microbiome actually improves plant health, resilience and productivity, and whether probiotic microbes can be integrated successfully into the core microbiome for lasting crop benefits.

The work was supported by the National Science Foundation (DEB 1754494). Other paper co-authors are Francis Cheng-Hsuan Weng of the Academia Sinica in Taipei, Taiwan, Pierre Joubert of UC Berkeley and Jessica Metcalf of Princeton University.

Journal Reference:

Norma M. Morella, Francis Cheng-Hsuan Weng, Pierre M. Joubert, C. Jessica E. Metcalf, Steven Lindow, Britt Koskella. Successive passaging of a plant-associated microbiome reveals robust habitat and host genotype-dependent selection. Proceedings of the National Academy of Sciences, 2019; 201908600 DOI: 10.1073/pnas.1908600116



Exceptional conditions call for exceptional analysis of your soil.

NEW METHODS PROMISE TO SPEED UP DEVELOPMENT OF NEW PLANT VARIETIES

A University of Minnesota research team recently developed new methods that will make it significantly faster to produce gene-edited plants. They hope to alleviate a long-standing bottleneck in gene editing and, in the process, make it easier and faster to develop and test new crop varieties with two new approaches described in a paper recently published in Nature Biotechnology.

Despite dramatic advances in scientists' ability to edit plant genomes using gene-editing tools such as CRISPR and TALENs, researchers were stuck using an antiquated approach - tissue culture. It has been in use for decades and is costly, labor intensive and requires precise work in a sterile environment. Researchers use tissue culture to deliver genes and gene editing reagents, or chemicals that drive the reaction, to plants.

"A handful of years ago the National Academy of Sciences convened a meeting of plant scientists, calling on the community to solve the tissue culture bottleneck and help realise the potential of gene editing in plants," said Dan Voytas, professor in Genetics, Cell Biology and Development in the College of Biological Sciences and senior author on the paper. "We have advanced genome editing technology but we needed a novel way to efficiently deliver gene editing reagents to plants. The methods in this paper present a whole new way of doing business."

The new methods will:

- drastically reduce the time needed to edit plant genes from as long as nine months to as short as a few weeks;
- work in more plant species than was possible using tissue culture, which is limited to specific species and varieties;
- allow researchers to produce genetically edited plants without the need of a sterile lab, making it a viable approach for small labs and companies to utilise.

To eliminate the arduous work that goes into gene-editing through tissue culture, co-first authors Ryan Nasti and Michael Maher developed new methods that leverage important plant growth regulators responsible for plant development.

Using growth regulators and gene editing reagents, researchers trigger seedlings to develop new shoots that contain edited genes. Researchers collect seeds from these gene-edited shoots and continue experiments. No cell cultures needed.

The approaches differ in how the growth regulators are applied and at what scale. The approach developed by Nasti allows small-scale rapid testing - with results in weeks instead of months or years - of different combinations of growth regulators. "This approach allows for rapid testing so that researchers can optimise combinations of growth regulators and increase their efficacy," he said.

Maher used the same basic principles to make the process more accessible by eliminating the need for a sterile lab environment. "With this method, you don't need sterile technique. You could do this in your garage," he said. He added that this technique opens up the possibility that smaller research groups with less resources can gene edit plants and test how well they do.

"Nasti and Maher have democratised plant gene editing. It will no longer take months in a sterile lab with dozens of people in tissue culture hoods," Voytas said.

The researchers used a tobacco species as their model, but have already demonstrated the method works in grape, tomato and potato plants. They believe the findings will likely transfer across many species. Plant geneticists and agricultural biotechnologists aim to ensure stable food sources for a growing global population in a warming climate, where pest outbreaks and extreme weather events are commonplace. These new methods will allow them to work more efficiently.

Journal Reference:

Michael F. Maher, Ryan A. Nasti, Macy Vollbrecht, Colby G. Starker, Matthew D. Clark, Daniel F. Voytas. Plant gene editing through de novo induction of meristems. Nature Biotechnology, 2019; DOI: 10.1038/s41587-019-0337-2

RESEARCH IDENTIFIES POSSIBLE ON/OFF SWITCH FOR PLANT GROWTH

New research from UC Riverside identifies a protein that controls plant growth - good news for an era in which crops can get crushed by climate change.

Researchers found the protein, IRK, while looking for clues to the ways plant cells divide or expand. They discovered IRK in the roots cells of a plant related to mustard.

> **"When this protein is present, the root perceives a signal that tells cells not to divide," said Jaimie Van Norman, who led the study and is an assistant professor of plant sciences at UCR. "If we can get the plant to ignore those signals, we may be able to get it to grow in conditions where it might not otherwise."**

The team's work on IRK was recently published in Developmental Cell. The research demonstrates that turning off the gene producing IRK causes an increase in the number of times the plant's root cells divide. Additional cells can lead to bigger roots, and perhaps to plants that are better at taking up nutrients from the soil and grow larger.

There may be some instances in which farmers also want to limit plant growth. For example, keeping weeds small, or trying to pause crop growth until a severe storm passes. IRK can be instrumental for both goals.

"This discovery gives us another way to control growth," Van Norman said. "Understanding how the plant itself stops growth can also allow us to accelerate growth."

So far, Van Norman's team has only tested the effects of turning off the IRK gene in Arabidopsis, the mustard relative. However, Van Norman said the IRK protein is also found in other crop plants.

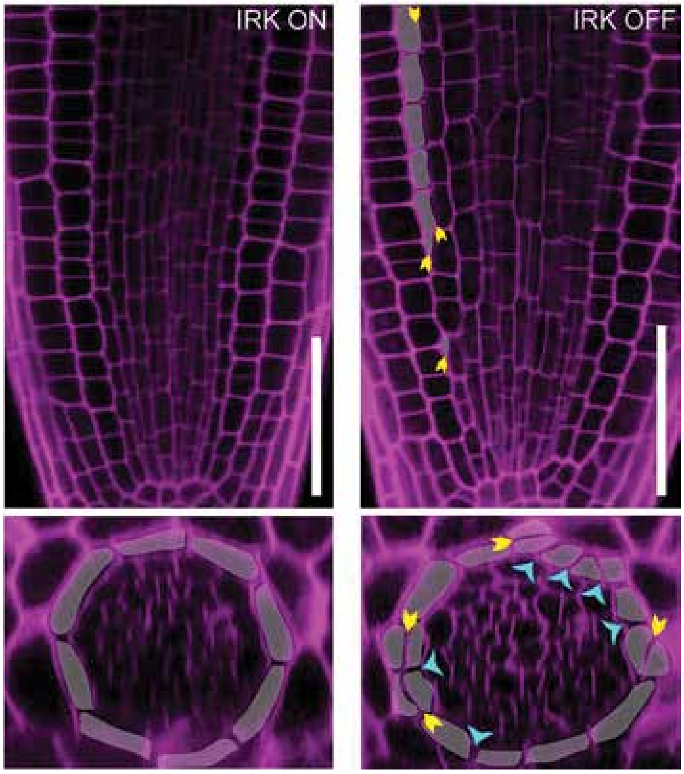
This research is notable not only for its potential impact on crop and food security, but also because roots have historically been less well studied than the above-ground parts of plants. This is likely due to the relatively inaccessible nature of roots, Van Norman said.

However, the roots are critical for plant survival and for the production of above-ground plant organs such as leaves flowers and fruits. Therefore, understanding their function and development is critical in efforts to improve crop productivity.

Previous research has examined the role of signals sent between cells up and down the plant from the roots up toward the shoots and vice versa. This study shows communication between cells across the root is important as well.

"There was a longstanding hypothesis that this type of horizontal communication between cells was important, and this work provides new evidence that it is," Van Norman said.

Next, Van Norman is hoping to understand whether bigger roots survive stress better. Some of the biggest challenges to crops include drought and high levels of salinity in soils.



Picture of strawberry wounding field experiment with 50 perforations per plant (W50)
Photo credit: Luis Cisneros-Zevallos

Salts accumulate in soil both from natural and human-made sources, such as fertilisers and salts in irrigation waters. If there is too much salt built up near the soil surface, it can prevent vital processes in plant growth and even cause crops to fail entirely.

Out of an abundance of caution and without accurate salinity measurements, farmers have traditionally over-irrigated their fields to send salts into lower soil depths where they are less harmful to crops. However, this practice is being scrutinised as both the quantity and quality of water becomes scarcer.

"It may be the case that by understanding what happens when the IRK-producing gene is turned off, we can make root growth less sensitive to soil conditions that pose a threat to food security," Van Norman said.

Journal Reference:

Roya Campos, Jason Goff, Cecilia Rodriguez-Furlan, Jaimie M. Van Norman. The Arabidopsis Receptor Kinase IRK Is Polarized and Represses Specific Cell Divisions in Roots. Developmental Cell, 2019; DOI: 10.1016/j.devcel.2019.12.001

ACCELERATING ADOPTION OF PRECISION AGRICULTURE THROUGH DATA INTEGRATION

Agronomists and farmers often have to switch between their farm management records and other dashboards (weather, machinery data, remotely sensed data, scouting apps) to derive an in-depth understanding of the condition of their fields. It takes time to transfer information between applications which translates into time and productivity loss, and underutilisation of valuable data for decision making.

To unlock the real value of in-field data, it needs to be contextualised alongside remote sensing imagery and geospatial information. Through the use of robust scientific models and machine learning techniques, this data can be turned into predictive models and insights to support agronomic analysis.

The integration breaks the silo allowing users to derive valuable insights from their data. They receive early, accurate and actionable information on farm performance and crop nutrition as well as proactive crop stress alerts. Nutrient application maps that previously took hours to create can now be auto-generated and acted upon quickly; automated crop stress detection, scouting recommendations, fertilisation prescriptions, directed herbicide applications, guided tissue or soil sampling can now be streamlined.

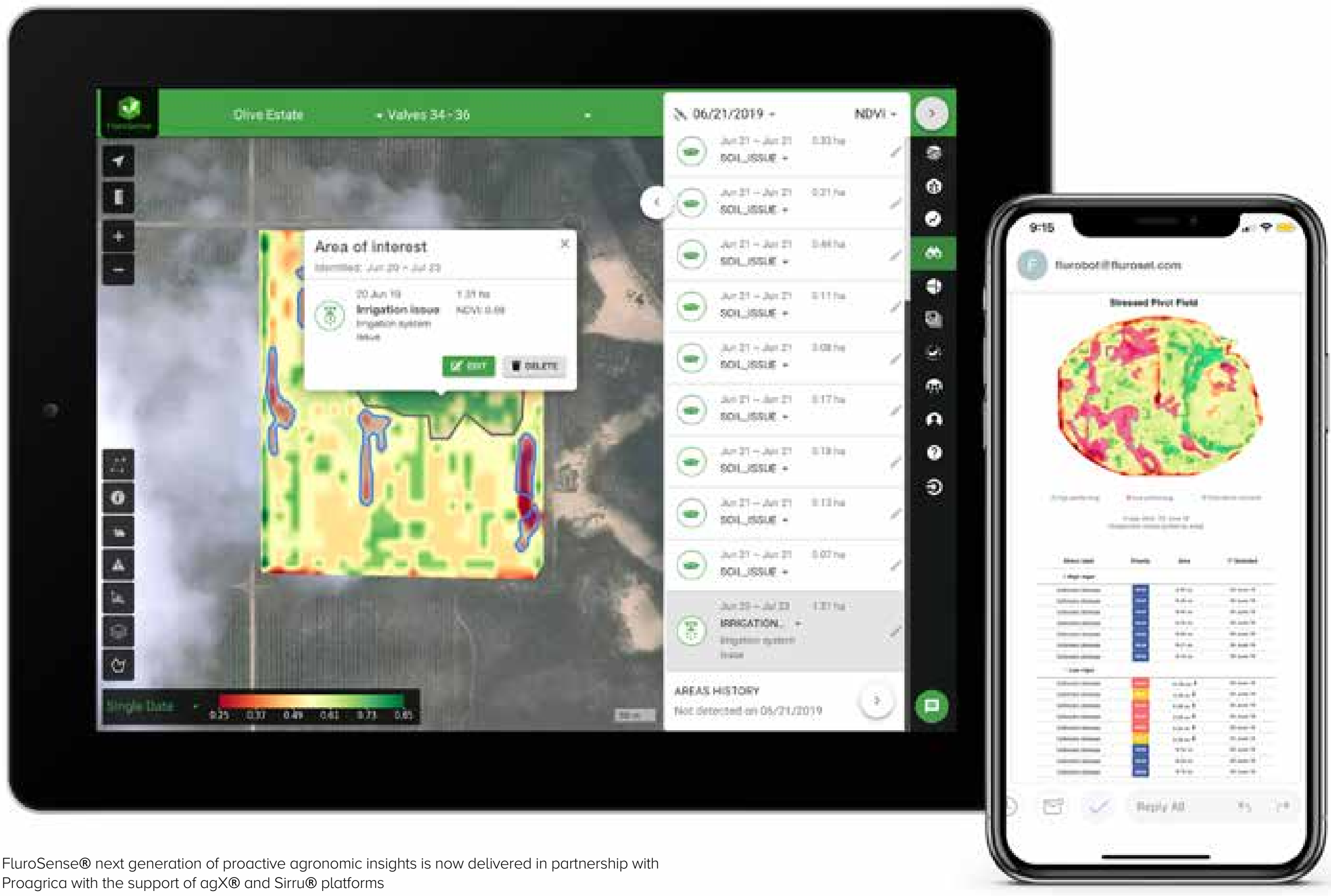
“Seasons wait for no man and the amount of data that agronomists have to look at is getting increasingly overwhelming. The ability to analyse these large data sets including remotely-sensed imagery of crops with variety, sowing time, weather conditions and sending accurate nutrient management prescriptions back to the tractor for growers to use are game-changers,” said Dr Anastasia Volkova, CEO & Founder, FluroSat.

“We have been receiving extremely positive feedback from our customers in the US who use FluroSense through our direct integration with Proagrica’s agX® platform. They are able to analyse huge volumes of data that are collected and delivered through Sirrus. They are already asking FluroSat to deliver more innovative applications that will also be directly integrated with agX so that they can reap the true benefits of precision agriculture,” concluded Ms Volkova.

“Our customers have long been calling for a single agronomy platform that allows them to make smarter decisions from the data they are already collecting,” said Mark Pawsey, Proagrica’s Business Development Director for Australia.

“We’re pleased to be partnering with FluroSat and through their analytics platform, provide our users with the benefits of a connected ecosystem to make management and production decisions at a more precise level using an integrated suite of tools”.

The partnership will see ongoing collaboration between FluroSat and Proagrica to bring more analytics capabilities together that can bring the value of enriched data to customers and users in Australia and the United States.



FluroSense® next generation of proactive agronomic insights is now delivered in partnership with Proagrica with the support of agX® and Sirru® platforms

PROMISING FRUIT FLY TRAP TO BE TESTED ON GRAPES

Agriculture Victoria scientists are set to trial a new trapping strategy in Victorian vineyards, in a bid to control a major horticulture pest.

The two-year research project, funded by Agriculture Victoria and Hort Innovation, will test the effectiveness of an attract-and-kill trapping strategy for managing Queensland fruit fly in table grape vineyards.

The project builds on current research that has developed a new trap targeting mating females Queensland fruit fly, and is showing considerable promise in stone fruit, pome fruit and citrus orchards.

Queensland fruit fly populations have escalated in recent years in Sunraysia - Victoria's major table grape-growing region - presenting a major and growing challenge to the industry in terms of productivity and maintaining access to export markets.

The insect causes significant damage to fruit crops by stinging fruit (laying eggs) and infecting them with larvae.

The trap, developed by Agriculture Victoria scientists, looks and smells like ripe fruit, tricking the female flies into landing on a sticky surface.

Agriculture Victoria research project lead, Dr Paul Cunningham, said the project aims to help growers develop a strategy to effectively manage Queensland fruit fly in table grapes.

"We see this trap as a valuable tool in an integrated pest management strategy to help reduce Queensland fruit fly populations across all Victoria's fruit industries," Dr Cunningham said.

"This will help protect Victoria's table grape industry by maintaining production and access to domestic and international markets."

The project will improve grower and industry knowledge of Queensland fruit fly management in table grapes through the delivery of best practice guidelines, workshops and on-farm trials. "This trial will fill a crucial knowledge gap in the control of Queensland fruit fly in table grapes," he said.

"If successful, adoption and integration of a mass trapping strategy using this trap could be seen within three to five years."

Australian Table Grape Association CEO Jeff Scott welcomed the trial.

"Any new technology in mitigating fruit fly would be welcomed by all horticulture industries, but particularly in Sunraysia where numbers are so high," Mr Scott said.

The trap was developed by Agriculture Victoria in collaboration with Hort Innovation and the Plant Biosecurity CRC.

NEW SUB-CLOVERS OFFER PRODUCTIVITY GAINS FOR AUSTRALIAN LIVESTOCK PRODUCERS

FOLLOWING A FIVE-YEAR JOINT VENTURE WITH THE DEPARTMENT OF AGRICULTURE AND FOOD WA (DAFWA) AND A $700K INVESTMENT FROM SEED FORCE, THERE ARE NOW EIGHT NEW SUB-CLOVER VARIETIES AVAILABLE TO AUSTRALIAN LIVESTOCK PRODUCERS.

The new varieties cover all three sub-species to cater for differing soil types and annual average rainfall from 325-1000mm. Most are now fully commercial with some still in limited supplies at this stage.

The gains from these new varieties include improved seed yield, resistance to major pests and diseases of sub-clover and ultimately higher forage yields and longer persistence.

The performance of sub-clover is a numbers' game - put simply, if sown seed can deliver plants that produce more seed, then they can produce more seedlings. And if those seedlings have improved resistance to pests and disease, that will result in more plants that survive to produce greater feed, especially in the autumn/winter period.

The new varieties from the Seed Force/DAFWA Joint Venture have all been bred with this in mind and have been selected after thorough multi-location, three-year replicated trials evaluating a final selection of 20-24 improved breeding lines of each sub-species compared with existing commercial varieties.

Subterranean clover (sub-clover) is a pasture legume native to the Mediterranean basin, the western Atlantic coast of Europe and west Asia. This makes it well adapted to other areas of the world with similar climates, such as southern Australia, where it is now a key part of our sustainable mixed grass and legume based pasture systems.

Plant features

Annual life cycle: Sub clover is an annual legume, which germinates in autumn and completes seed production in spring/early summer (timing depends on cultivar).

Natural re-seeding: Sub clover regenerates naturally each year from seed set in previous years, without the need for re-sowing.

Easy-care grazing: Sub clover is very grazing tolerant, due to its prostrate growth habit, flowering close to the ground and burial of its seed-containing burrs.

Persistence over seasons: Sub clover is a reliable seed producer. Most seeds germinate in the following autumn, but some seeds remain dormant as 'hard seeds' (the proportion depends on cultivar), which 'soften' over subsequent summers for germination. This results in natural re-seeding even after poor seasons for seed production.

High feed quality: Green sub clover has similar feed quality characteristics to lucerne and white clover with high energy and provides protein to meet all livestock minimum requirements.

Improved soil fertility: Sub clover fixes nitrogen, with the aid of Rhizobium bacteria, for its own growth and supplies N to other grasses and herbs in the pasture. It also provides N in the soil for crops and other plants in following years. In general it will produce around 20kg N per tonne of dry matter produced.

Subspecies and soil type suitability

Sub clover consists of three subspecies, adapted to different soils.

ssp. subterraneum is adapted to well-drained, moderately acid (pHCa 4.5 - 6.5) soils. Most cultivars belong to this group. This type actively buries it burrs.

Seed Force has released four new subterraneums each with seedling resistance to red-legged earth mite and suited to varying growing season length with **SF Tammin** (88 Days to Flower), **SF Forbes** (101 DTF), **SF Narrikup** (126 DTF), and **SF Rosabrook** (140 DTF).

ssp. yanninicum is also suited to moderately acid (pHCa 4.5 - 6.5) soils, but is well adapted to waterlogged or poorly drained soils and to soils that hold their moisture. They actively bury their burrs.

Seed Force has released two new yanninicums with improved seed yield and resistance to clover scorch. They are suited to mid to late growing season lengths with **SF Yanco** (121 DTF), and **SF Rouse** (131 DTF).

ssp. brachycalycinum is best suited to well-drained, neutral-alkaline (pHCa 6.0 - 8.0) soils. They have long, thin burr stalks and seek out cracks or stones to develop their burrs, rather than actively burying them.

Seed Force has released two new brachycalycinums with improved seed yield and resistance to clover scorch and powdery mildew. They are suited to mid to late growing season lengths with **SF Tarlee** (130 Days to Flower), and **SF Antillo** (138 DTF).

Use of subterranean clover in southern Australia

Sub clover is well adapted to the Mediterranean-type climate (mild, wet winters and hot, dry summers) of southern Australia, where it has been sown over an estimated 29 million ha. A range of cultivars, differing in flowering times, enables it to be grown in environments with annual average rainfall ranging from 275 mm to 1,200 mm.

In high rainfall areas sub clover is generally sown in permanent pastures, often with perennial grasses, while in low and medium rainfall areas it is often grown in rotation with crops. It is grazed by both sheep and cattle.

Its prostrate growth habit makes it particularly well suited to prolonged heavy grazing by sheep. Excess pasture in spring is often cut for conserved fodder (hay or silage), although more erect species are better suited to this. Dry pasture residues over summer are grazed.

You should select the correct sub-species (subterranean, yanninicum, brachycalycinum or mix) for different soil types in your paddock. Then select the most appropriate variety for your rainfall.

It is often advisable to mix 2-3 varieties to cover the fact that seasons and rainfall can vary by year.

For example, a mix or **SF Narrikup** and **SF Rosabrook** could be used in 600-650 mm rainfall to cover higher or lower rainfall years, or a mix of SF Rouse and **SF Rosabrook** could be used where parts of a paddock can become waterlogged in some years but rainfall is reliable.

Seed Force has a sub-clover selection chart available showing all varieties (past & current) in Australia allowing an easy comparison and suitability for specific rainfall, season length and soil types.

This is included in this edition of the Agronomist magazine.
A digital version can be accessed on the Seed Force website **www.seedforce.com**

DAFWA team with SF Rouse Manjimup WA

DAFWA team with SF Rouse Manjimup WA

Manjimup sub-clover trial site

Sub-clover PBR trial Shenton Park WA

HOW FLOWERS ADAPT TO THEIR POLLINATORS

Flowering plants are characterised by an astonishing diversity of flowers of different shapes and sizes. This diversity has arisen in adaptation to selection imposed by different pollinators including among others bees, flies, butterflies, hummingbirds, bats or rodents. Although several studies have documented that pollinators can impose strong selection pressures on flowers, our understanding of how flowers diversify remains fragmentary. For example, does the entire flower adapt to a pollinator, or do only some flower parts evolve to fit a pollinator while other flower parts may remain unchanged?

In a recent study, scientists around Agnes Dellinger from the Department of Botany and Biodiversity Research from the University of Vienna investigated flowers of 30 species of a tropical plant group (Merianieae) from the Andes. "Each of these plant species has adapted to pollination by either bees, birds, bats or rodents," says Dellinger. Using High-Resolution X-ray computed tomography, the research team produced 3D-models of these flowers and used geometric-morphometric methods to analyse differences in flower shape among species with different pollinators.

The researchers could show that flower shapes have evolved in adaptation to the distinct pollinators, but that flower shape evolution was not homogeneous across the flower. In particular, the showy sterile organs of flowers (petals) adapted to the different pollinators more quickly than the rest of the flower: the reproductive organs have evolved more slowly.

"This study is among the first to analyse the entire 3-dimensional flower shape, and it will be exciting to see whether similar evolutionary floral modularity exists in other plant groups," concludes Dellinger.

Journal Reference:

Agnes S. Dellinger, Silvia Artuso, Susanne Pamperl, Fabián A. Michelangeli, Darin S. Penneys, Diana M. Fernández-Fernández, Marcela Alvear, Frank Almeda, W. Scott Armbruster, Yannick Staeder, Jürg Schönenberger. Modularity increases rate of floral evolution and adaptive success for functionally specialized pollination systems. Communications Biology, 2019; 2 (1) DOI: 10.1038/s42003-019-0697-7

TINY WOODLANDS ARE MORE IMPORTANT THAN PREVIOUSLY THOUGHT

Small woodlands in farmland have more benefits for humans per area, compared to large forests according to a new study. The small woodlands, sometimes even smaller than a football field, can easily go unnoticed in agricultural landscapes. Yet, these small forest remnants can store more carbon in the topsoil layer, are more suitable for hunting activities and host fewer ticks than large forests.

"The value of these tiny forests has never been unraveled before, although the occurrence of small woodlands in agricultural landscapes has increased due to forest fragmentation," says Alicia Valdés, one of the authors of the study.

The reason why these tiny woodlands may provide us with more services is because they naturally have more edges exposed to the influence of the surrounding environment.

"For example, there is more food supply for roe deer, such as blueberries and seedlings of birch and oak, because edges receive more sunlight and nutrients from the surrounding farmlands. This in turn, is predicted to attract more roe deer that can be hunted by humans," says Alicia Valdés.

These tiny forests can also store more carbon per area in the topsoil layer than older big woodlands, because they have an increased soil biological activity, which makes them faster at absorbing organic matter. Potentially these can act as better carbon sinks and help counterbalance the effects of global warming.

Another benefit of the tiny forests is that they represent a lower risk of contracting a tick borne disease. This is because less tick larvae can survive in the dry and hot environments characterising woodland edges.

"This is just a prediction of all the potential benefits. How people would use these is something that needs to be looked into," says Alicia Valdés.

Now that the authors found out that the smaller woodlands are of greater value than previously thought, they argue that more conservation efforts are needed to maintain their important role and value in agricultural landscapes.

"Preserving the large forests is important because of their higher biodiversity, but conserving smaller woodlands, especially the older ones, will help to increase human well being in agricultural landscapes. These small woodlands need specific policy instruments ensuring their future conservation," says Alicia Valdés.

Journal Reference:

Alicia Valdés, Jonathan Lenoir, Pieter De Frenne, Emilie Andrieu, Jörg Brunet, Olivier Chabrerie, Sara A. O. Cousins, Marc Deconchat, Pallieter De Smedt, Martin Diekmann, Steffen Ehrmann, Emilie Gallet-Moron, Stefanie Gärtner, Brice Giffard, Karin Hansen, Martin Hermy, Annette Kolb, Vincent Le Roux, Jaan Liira, Jessica Lindgren, Ludmilla Martin, Tobias Naaf, Taavi Paal, Willem Proesmans, Michael Scherer-Lorenzen, Monika Wulf, Kris Verheyen, Guillaume Decocq. High ecosystem service delivery potential of small woodlands in agricultural landscapes. Journal of Applied Ecology, 2019; DOI: 10.1111/1365-2664.13537

SORGHUM STUDY ILLUMINATES RELATIONSHIP BETWEEN HUMANS, CROPS AND THE ENVIRONMENT IN DOMESTICATION

A new study that examines the genetics behind the bitter taste of some sorghum plants and one of Africa's most reviled bird species illustrates how human genetics, crops and the environment influence one another in the process of plant domestication.

The study untangles these factors to create a more complete look at crop domestication than is possible in other major crops, said Xianran Li, an adjunct associate professor in the Iowa State University Department of Agronomy and corresponding author of the paper. The study, published recently in the scientific journal Nature Plants, looked at how human genetics, and the presence of bird species with a taste for sorghum seeds might have influenced the traits farmers in Africa selected in their crops over thousands of years.

The unique geographic distribution in Africa of sorghum plants that contain condensed tannins, or biomolecules that often induce a bitter taste, provided one side of a "domestication triangle" that helped the researchers piece together the domestication puzzle, Li said.

"It's a systematic view that gives us a full picture of domestication," he said. "Looking at just one component only tells us part of the story."

Sorghum is a cereal crop first domesticated in Africa that remains a staple food throughout the continent. The researchers noted that sorghum varieties with high levels of tannins commonly grow in eastern and southern Africa, while western African farmers tend to prefer varieties with low tannin content. In contrast, domestication processes in other continents removed condensed tannins from most other cereal crops, such as wheat, rice and corn, due to the bitter taste they produce.

But farmers in south and east Africa grow many cultivars that retained tannin, which would seem to be a puzzling decision considering the taste and unfavourable nutritional values. Li said the condensed tannins were likely retained as a defence mechanism from the red-billed quelea, a bird species sometimes referred to as a "feathered locust" that can cause up to $50 million in economic losses in Africa every year from eating crops. Li and his co-authors found the distribution of sorghum cultivars with tannin correspond to areas with red-billed quelea populations.

They also consulted publicly accessible genotype information on human populations in Africa and found an associated distribution of the taste receptor TAS2R among Africans in regions that commonly grow sorghum with tannin. Taste receptors are molecules that facilitate the sensation of certain tastes, and the patterns in the distribution of TAS2R could make people living in those regions of Africa less susceptible to the bitter taste caused by tannin.

Li called this unique interaction among sorghum tannin, human taste receptors and herbivorous birds a unique triangle that offers unique insight into crop domestication. And, because condensed tannins were bred out of other cereal crops, this kind of research is possible only with sorghum, he said.

"Our investigation uncovered coevolution among humans, plants and environments linked by condensed tannins, the first example of domestication triangle," Li said. "The concept of a domestication triangle has been proposed previously and generally accepted. Discovering a concrete case, particularly with some molecular evidence, is very exciting. We think this study could help uncover future cases."

To arrive at their conclusions, the research team grew sorghum varieties with and without tannin and analyzed publicly available datasets on human genetics and wild bird populations in Africa to untangle how these factors interact with one another to influence the domestication of sorghum in Africa. The experiments involving sorghum grown in Iowa found sparrows would feed on the seeds of plants without tannin but left alone the cultivars that contained tannin, reinforcing the concept that herbivore threats to sorghum crops prefer non-tannin varieties.

"The whole discovery was driven by curiosity, after we observed the unexpected sparrow damage in our sorghum field," said Jianming Yu, professor of agronomy and Pioneer Distinguished Chair in Maize Breeding. "We really had no clue that our gene cloning project to find the pair of interacting genes underlying sorghum tannins would lead to this discovery."

Journal Reference:

Yuye Wu, Tingting Guo, Qi Mu, Jinyu Wang, Xin Li, Yun Wu, Bin Tian, Ming Li Wang, Guihua Bai, Ramasamy Perumal, Harold N. Trick, Scott R. Bean, Ismail M. Dweikat, Mitchell R. Tuinstra, Geoffrey Morris, Tesfaye T. Tesso, Jianming Yu, Xianran Li. Allelochemicals targeted to balance competing selections in African agroecosystems. Nature Plants, 2019; 5 (12): 1229 DOI: 10.1038/s41477-019-0563-0

PLANTS' 'ORGANIC' WOUNDS IMPROVE PRODUCE

Texas A&M AgriLife Research scientists found benefits of insect leaf-wounding in fruit and vegetable production. Stress responses created in the fruits and vegetables initiated an increase in antioxidant compounds prior to harvest, making them healthier for human consumption.

"Many studies in the past supported this idea, but many others showed no differences," said Luis Cisneros-Zevallos, Ph.D., AgriLife Research horticulture and food scientist in College Station and principal investigator for a study addressing this controversy. "In our study we proved that wounding leaves in plants like those caused by insects produce healthier organic fruit."

The study "Solving the controversy of healthier organic fruit: Leaf wounding triggers distant gene expression response of polyphenol biosynthesis in strawberry fruit (Fragaria x ananassa)." was pubished in Scientific Reports from Nature. The research team, highly interdisciplinary in nature, also included molecular biologist Woo Young Bang, Ph.D., and horticulturist Leonardo Lombardini, Ph.D., both former AgriLife Research scientists.

"We conducted studies using strawberries as a crop model and applied various levels of wounding to the leaves a few days before harvesting the fruit. We found how several genes associated with sugar translocation and phenolic compound biosynthesis were over-expressed in the distant strawberry fruit," said Facundo Ibanez, Ph.D., an investigator for the project associated with the Instituto Nacional de Investigacion Agropecuaria, Uruguay.

All plants have the ability to respond to the environment by activating the secondary metabolism as part of a defence mechanism or as part of an adaptation process. It also activates the primary metabolism, which will move the carbon source needed to produce those antioxidant compounds, explained Cisneros-Zevallos.

"There was the existing idea proposed by others that insects present in the field in organic farming could cause a stress response in the plant and increase antioxidant compounds," said Cisneros-Zevallos. "However, this hypothesis or concept was never tested until now, where we mimicked the damage caused by insects."

Ibanez said the study emphasised fresh produce as an excellent source of health-promoting compounds and that perhaps insects in some way can be allies to achieve even healthier produce.

"Healthier grown produce for the food industry can be a driving force for large-scale production and an attractive investment to relevant stakeholders," he said.

Organic farming in recent years has experienced continued growth and a higher demand among consumers. This has had a positive large-scale impact on the organic industry, farmers and other industries related to organic produce, said Cisneros Zevallos.

After several studies published in the past on post-harvest wounding stress effects on different crops, the team was inspired to apply this approach to leaf surfaces in the field that mimicked the attack of insects to the plant.

"This observation was key when we designed the strategies to be used in the study, that simple wounding stress on leaf surfaces elicited this systemic response with the unique observation of higher accumulation of phenolic antioxidants in fruit," Ibanez said.

"Our team has elucidated a controversy that was an open question for many years," Cisneros-Zevallos said. "Understanding how these antioxidants are produced by a simple stress like wounding can certainly transform the way the fresh produce industry operates, including both organic and conventional. And it may allow the industry to adopt novel tools based on pre-harvest stress to favour the accumulation of healthier antioxidants in fresh produce and processed foods."

Journal Reference:

Facundo Ibanez, Woo Young Bang, Leonardo Lombardini, Luis Cisneros-Zevallos. Solving the controversy of healthier organic fruit: Leaf wounding triggers distant gene expression response of polyphenol biosynthesis in strawberry fruit (Fragaria x ananassa). Scientific Reports, 2019; 9 (1) DOI: 10.1038/s41598-019-55033-w

Picture of strawberry wounding field experiment with 50 perforations per plant (W50)
Photo credit: Luis Cisneros-Zevallos

BAYER
One choice.
Two options.
sakura®
Flow
Sakura®, the proven pre-eminent pre-emergent, is now available in a liquid SC formulation. Sakura Flow delivers the same class-leading control of annual ryegrass and other key grass weeds as the WG formulation.
• Concentrated 480 g/L formulation
• Low application rate of 210 mL/ha
• Up to 12 weeks long-lasting residual control of key grass weeds
• Group K herbicide mode of action
POISON
KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING
sakura
Flow
HERBICIDE
AXEEV
20 L
POISON
sakura
HERBICIDE
AXEEV
NEW
LIQUID OPTION
NOW AVAILABLE

BIODIVERSITY YIELDS FINANCIAL RETURNS

Many farmers associate grassland biodiversity with lower yields and financial losses. "Biodiversity is often considered unprofitable, but we show that it can, in fact, pay off," says Nina Buchmann, Professor of Grassland Sciences at ETH Zurich. In an interdisciplinary study at the interface of agricultural sciences, ecology and economics, Buchmann and her colleagues were able to quantify the economic added value of biodiversity based on a grassland experiment that examined different intensities of cultivation. Their paper was published in the journal Nature Communications.

Creating higher revenues

"Our work shows that biodiversity is an economically relevant factor of production," says Robert Finger, Professor of Agricultural Economics and Policy at ETH Zurich. If 16 different plant species grow in a field instead of just one, the quality of the forage remains more or less the same, but the yield is higher - which directly correlates to the income that can be made from milk sales. "The resultant increase in revenues in our study is comparable to the difference in yield between extensively and intensively farmed land," says Sergei Schaub, lead author of the study and a doctoral student in Finger's and Buchmann's groups.

Switzerland has so-called ecological compensation areas, i.e., grasslands for which farmers pay particular attention to promoting biodiversity. However, these areas often have poor soils and the yields they produce cannot be compared with those of high-quality grassland. Fortunately, the researchers were able to use data from the long-term Jena Experiment, which - among other questions - compared different farming practices at the same site.

"Our results show that biodiversity has an economically positive effect on all areas, regardless of whether farmers mow and fertilise them four times a year or just once," Schaub says.

The more intensely the land is farmed, however, the more difficult it becomes to maintain a high level of biodiversity, because only a few plant species can withstand fertilisation and frequent mowing, he notes. Finger adds that Swiss farmers already take more advantage of this economic effect than their counterparts in other countries. Generally speaking, biodiversity on the areas used for forage production in Switzerland is already relatively rich in biodiversity because the seed mixtures are adapted to local conditions, he explains.

Biodiversity as risk insurance

The researchers didn't expect their results to be so conclusive. And there's another economic aspect that they didn't even factor in: "Biodiversity is also a kind of risk insurance," Buchmann says. Diverse grasslands are better off to cope with extreme events such as droughts or floods, he explains, because different plant species react differently to such environmental influences, which partially compensates for any losses arising. "This means yields become more stable over time," Buchmann says, as the research team demonstrated in other recent studies.

The researchers believe their results are a clear indication that it's worthwhile for farmers to increase the diversity of plants growing on their land. "Preserving or restoring diverse grasslands can be a win-win situation," the researchers note at the end of their paper. Not only because this increases farmers' yields and operating revenues, but also because it improves and promotes important ecosystem services such as pollination or water quality.

Journal Reference:

Schaub S, Finger R, Leiber F, Probst S, Kreuzer M, Weigelt A, Buchmann N and Scherer- Lorenzen M. Plant diversity effects on forage quality, yield and revenues of semi- natural grasslands. Nat. Comm. (2020). DOI 10.1038/s41467- 020-14541-4

A meadow with more than ten species yields more than a meadow with only one species. Photo credit: Valentin Klaus

A NEW TOMATO IDEAL FOR URBAN GARDENS AND EVEN OUTER SPACE

Farmers could soon be growing tomatoes bunched like grapes in a storage unit, on the roof of a skyscraper, or even in space. That's if a clutch of new gene-edited crops prove as fruitful as the first batch.

The primary goal of this new research is to engineer a wider variety of crops that can be grown in urban environments or other places not suitable for plant growth, said Cold Spring Harbor Laboratory Professor and HHMI Investigator Zach Lippman, who leads the lab that designed the 'urban agriculture tomatoes.'

These new gene-edited tomato plants look nothing like the long vines you might find growing in a backyard garden or in agricultural fields. The most notable feature is their bunched, compact fruit. They resemble a bouquet whose roses have been replaced by ripe cherry tomatoes. They also mature quickly, producing ripe fruit that's ready for harvest in under 40 days. And you can eat them.

"They have a great small shape and size, they taste good, but of course that all depends on personal preference," Lippman said.

Most importantly, they're eco-friendly.

"This demonstrates how we can produce crops in new ways, without having to tear up the land as much or add excessive fertiliser that runs off into rivers and streams," Lippman said. "Here's a complementary approach to help feed people, locally and with a reduced carbon footprint."

That's good news for anyone concerned about climate change. Earlier this year, the UN Intergovernmental Panel on Climate Change (IPCC) warned that more than 500 million people are living on land already degraded by deforestation, changing weather patterns, and overuse of viable cropland. By shifting some of the burden of growing the world's crops to urban and other areas, there's hope that desperate land mismanagement will slow.

Urban agricultural systems often call for compact plants that can be slotted or stacked into tight spaces, such as in tiered farming in warehouses or in converted storage containers. To make up for crop yield constrained by limited space, urban farms can operate year-round in climate-controlled conditions. That's why it's beneficial to use plants that can be grown and harvested quickly. More harvests per year results in more food, even if the space used is very small.

Lippman and his colleagues created the new tomatoes by fine-tuning two genes that control the switch to reproductive growth and plant size, the SELF PRUNING (SP) and SP5G genes, which caused the plant to stop growing sooner and flower and fruit earlier. But Lippman's lab knew it could only modify the SP sister genes only so much before trading flavour or yield for even smaller plants.

"When you're playing with plant maturation, you're playing with the whole system, and that system includes the sugars, where they're made, which is the leaves, and how they're distributed, which is to the fruits," Lippman said.

Searching for a third player, Lippman's team recently discovered the gene SIER, which controls the lengths of stems. Mutating SIER with the CRISPR gene-editing tool and combining it with the mutations in the other two flowering genes created shorter stems and extremely compact plants.

Lippman is refining this technique, published in the latest issues of Nature Biotechnology, and hopes others will be inspired to try it on other fruit crops like kiwi. By making crops and harvests shorter, Lippman believes that agriculture can reach new heights.

"I can tell you that NASA scientists have expressed some interest in our new tomatoes," he said.

While the first ship to Mars probably won't have its own farm, astronauts may still get to test their green thumbs with urbanised, space-faring tomatoes.

Journal Reference:

Choon-Tak Kwon, Jung Heo, Zachary H. Lemmon, Yossi Capua, Samuel F. Hutton, Joyce Van Eck, Soon Ju Park, Zachary B. Lippman. Rapid customization of Solanaceae fruit crops for urban agriculture. Nature Biotechnology, 2019; DOI: 10.1038/s41587-019-0361-2

DRONES EFFECTIVE TOOLS FOR FRUIT FARMERS

People have used the phrase "drone on and on" for a long time. Webster's dictionary defines this figure of speech as "to speak for a long time in a dull voice without saying anything interesting."

Yet, in agriculture, drones aren't dull, at all!

Farmers use drones to be more efficient. Drones help farmers improve yields and stay ahead of problems before they become too big.

Olga Walsh, University of Idaho, is researching the use of drones for fruit trees. Most of the agricultural applications for drones - or, more technically unmanned aerial vehicles (UAV) - have been on grain crops like wheat, corn and soy.

"Adoption and use of crop sensors in production agriculture saves thousands of dollars every year in many crops," says Walsh. "Crop sensors also help to significantly improve the efficiency of agricultural inputs, such as fertilisers and water. Finally, drones can minimise negative impacts of agricultural activities on environmental quality."

In Idaho, the fruit industry grows grapes, cranberries, apples, and even alternative fruits like Asian pears. Apples are the largest fruit crop in Idaho, with over 60 million pounds of apples produced per year.[1]

Walsh's research team focused on applying UAV technology to fruit trees. Her previous work has been with wheat and other crops. "We know drones can be used in orchards," says Walsh. "But there aren't any grower recommendations regarding what data needs to be collected and what kind of data is most useful, depending on the grower objective."

The most promising ways the drones could be employed for the orchards and tree nurseries are:

- taking inventory of tree height and canopy volume;
- monitoring tree health and quality;
- managing water, nutrients, pests and disease in-season;
- estimating fruit/nut production and yield; and,
- creating marketing tools (videos for promotion of the orchard, or sale of trees and fruit).

Like with other uses of drones in agriculture, Walsh's work helps to collect detailed information about the crops, faster than humans could by physically "scouting" the fields. "The UAVs are capable of acquiring images with high resolutions that are ideal for detecting various crop issues," says Walsh.

"The UAV systems allow scanning the crops from above. They obtain high quality images and high-resolution spectral data. This is correlated with plant growth, health, water and nutrient status, and can be used to estimate biomass production." All are indicators of potential yield.

It's not just about the speed of scouting a field. "Sensors can function within regions of the electromagnetic spectrum where human eyes can't," says Walsh. "Sensors are much more reliable and objective than visual assessment. They provide quantitative information (numeric data that can be measured and compared) versus qualitative information (descriptive data that can be observed)."

Team members also perform outreach. "We conduct grower education on the use of remote sensing and using UAVs for crop monitoring," says Walsh. "We do demonstration flights and produce publications to boost grower adoption of precision agriculture methods."

"The overall goal of this work is to strengthen sustainability and competitiveness of Idaho fruit tree producers," says Walsh. "Our findings increased awareness, knowledge, and adoption of crop sensors and UAVs."

And, that's not dull at all!

Walsh presented her work at the November International Annual Meeting of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America in San Antonio. Funding for this project came from the Idaho State Department of Agriculture Nursery Advisory and Florist Advisory Committee.

Reference:

1. https://agri.idaho.gov/main/about/about-idaho-agriculture/idaho-crops/

WATER HYACINTH - DON'T BUY, SELL OR GIVE IT AWAY

Water hyacinth is a highly invasive weed that is choking lakes, rivers and water ways around the world and Agriculture Victoria is encouraging Victorians to report it to prevent it from taking hold in Victoria.

Water hyacinth may look pretty but has a well-deserved reputation for being the world's worst water weed.

An advertising campaign, 'Water hyacinth - don't buy, sell or give it away', targets the illegal buying or selling of the State prohibited weed - the highest category of declared noxious weeds in Victoria.

The campaign will run on social media and online advertising sites in English, Mandarin, Khmer and Vietnamese.

Agriculture Victoria Biosecurity Manager - High Risk Invasive Plants, Angela Constantine said water hyacinth (Eichhornia crassipes), was very harmful in aquatic environments.

Ms Constantine said water hyacinth could rapidly affect water quality, native aquatic plants and fish, and have an impact on recreational activities such as fishing and boating.

"We are asking people, if they see water hyacinth, to contact Agriculture Victoria and we will remove it before it can spread further," Ms Constantine said.

It is illegal to buy, sell, display, propagate or transport State prohibited weeds.

Ms Constantine said in recent years Agriculture Victoria had prosecuted people for selling water hyacinth on Facebook and Gumtree.

"It's important to know what you are buying, selling, or giving away," she said.

Last financial year, Agriculture Victoria detected 21 cases of water hyacinth being traded online, and nine of these were in Victoria.

Ms Constantine said water hyacinth was easier to recognise during summer when it was flowering.

"Water hyacinth can be identified by its distinctive mauve flower and bulbous spongy stems," Ms Constantine said.

"It is often kept for its very attractive flower but owners may be unaware of the profound threat it poses.

"In just one season, a single plant can produce more than 3000 seeds that can survive for more than 20 years."

If you see or have any water hyacinth, or any other State prohibited weed, report it to the Agriculture Victoria Customer Service Centre on 136 186 or email weed.spotters@ecodev.vic.gov.au.

GRAIN TRAITS TRACED TO 'DARK MATTER' OF RICE GENOME

Domesticated rice has fatter seed grains with higher starch content than its wild rice relatives - the result of many generations of preferential seed sorting and sowing. But even though rice was the first crop to be fully sequenced, scientists have only documented a few of the genetic changes that made rice into a staple food for more than half the world's population.

New research now finds that a sizeable amount of domestication-related changes in rice reflects selection on traits that are determined by a portion of the genome that does not transcribe proteins.

Xiaoming Zheng, a biologist with the Institute of Crop Sciences at the Chinese Academy of Agricultural Sciences, is the first author of newly published paper in Science Advances, "Genome-wide analyses reveal the role of non-coding variation in complex traits during rice domestication." Qingwen Yang and Jun Liu, also from the Institute of Crop Sciences in the Chinese Academy of Agricultural Sciences, and Kenneth M. Olsen from Washington University in St. Louis are also communicating authors of this paper.

Noncoding RNAs are suspected to play very important roles in regulating growth and development, but they're only beginning to be characterised.

"Despite almost 20 years of genomics and genome-enabled studies of crop domestication, we still know remarkably little about the genetic basis of most domestication traits in most crop species," said Olsen, professor of biology in Arts & Sciences at Washington University.

"Early studies tended to go for 'low-hanging fruit' - simple traits that were controlled by just one or two genes with easily identifiable mutations," Olsen said. "Far more difficult is figuring out the more subtle developmental changes that were critical for a lot of the changes during crop domestication.

"This study offers a step in that direction, by examining one regulatory mechanism that has been critical for modulating domestication-associated changes in rice grain development."

Diversity of traits

A large proportion of the DNA in the chromosomes of many plants and animals comprises genes that do not encode instructions for making proteins - up to 98% of the genome for any given species. But this genetic information is poorly understood. Some scientists have called this stuff the 'dark matter' of the genome, or even dismissed it as 'junk DNA' - but it appears to have played an outsized role in rice development.

In this study, researchers found that key changes that occurred during rice domestication more than 9,000 years ago could be tied back to molecules called long-noncoding RNAs (lncRNAs), a class of RNA molecules with a length of more than 200 nucleotides.

About 36 percent of the genetic information recorded in the rice genome can be tracked back to noncoding regions, but more than 50 percent of the diversity of traits important to agriculture is linked to these same areas, the researchers found.

"For the first time, the lncRNAs in noncoding region of cultivated rice and wild rice was deeply annotated and described," Zheng said.

"Our transgenic experiments and population genetic analysis convincingly demonstrate that selection on lncRNAs contributed to changes in domesticated rice grain quality by altering the expression of genes that function in starch synthesis and grain pigmentation," she said.

Working with several hundred rice samples and more than 260 Gbs of sequence, the researchers employed sensitive detection techniques to quantify and robustly track lncRNA transcription in rice. The new study validates some previously identified lncRNAs and also provides new information on previously undescribed molecules.

This new study adds fuel to speculation by some researchers that most adaptive differences between groups of plants or animals are due to changes in gene regulation, and not protein evolution.

"Based on our findings, we propose that selection on lncRNAs could prove to be a broader mechanism by which genome-wide patterns of gene expression can evolve in many species," Zheng said.

This rice study also opens eyes and possibly new doors for producing new crops and grains through precision breeding.

Journal Reference:

X. M. Zheng, J. Chen, H. B. Pang, S. Liu, Q. Gao, J. R. Wang, W. H. Qiao, H. Wang, J. Liu, K. M. Olsen, and Q. W. Yang. Genome-wide analyses reveal the role of noncoding variation in complex traits during rice domestication. Science Advances, 2019 DOI: 10.1126/sciadv.aax3619

FIRST 'LAB IN A FIELD' EXPERIMENT REVEALS A SUNNIER SIDE OF CLIMATE CHANGE

Pioneering experiments using heated field plots to test the responses of crops to temperature have revealed an unexpected plus side of climate change for farmers.

The field trial experiment - the first of its kind - was set up to investigate the link between warmer Octobers in the United Kingdom and higher yields of oilseed rape.

The crop, planted in autumn and harvested early the following summer, is particularly sensitive to temperature at certain times of the year with annual yields varying by up to 30 percent as a result. It is known that warmer temperatures in October are correlated with higher oilseed rape yields, but the reason for this trend was unclear.

The results of this study by the John Innes Centre reveal that the temperature in October is surprisingly important for the timing of flowering, and that warmer Octobers result in a delay to flowering the following spring.

Professor Steve Penfield an author of the study says, "We found that oilseed rape plants stop growing when they go through the floral transition at the end of October, and that warmer temperatures at this time of year enable the plant to grow for longer, giving more potential for higher yields."

The good news for growers of oilseed rape is that Met Office data shows cold Octobers are now much less frequent than they were in the past.

"By establishing the link between autumn temperatures and yield, our study highlights an example of climate change being potentially useful to farmers. Cold Octobers have a negative effect on yield if you are growing oilseed rape, and these are now rarer," says Professor Penfield.

Temperature is critical for oilseed rape lifecycle because it determines at what point the plant goes through the transition from vegetative state to flowering, with delays in flowering being associated with higher yields.

This process called vernalisation is well understood in the lab as a requirement of a prolonged exposure to cold temperature. But an increasing body of research suggests vernalisation might work differently under more variable conditions experienced by a plant in the field.

In this study the team used soil surface warming cables to raise the temperature of field plots by between 4 and 8 degrees Celsius, simulating warmer October temperatures. Two varieties of oilseed rape with differing vernalisation requirements were trialled.

Lab tests on dissected plants showed that warming in October conditions delayed floral transition by between 3 and 4 weeks for both varieties. Genetic tests showed genes associated with vernalisation in cold conditions were also highly expressed in the warm conditions.

The study shows that vernalisation in oilseed rape takes place predominantly during October during which time the mean temperature is between 10-12 degrees Celsius.

The technology used in the study has been used before in natural grasslands to simulate winter warming but the trials conducted by the John Innes Centre research team are the first time it's been used on a crop in the field.

"This study was only possible because were able to create the lab into a field to simulate how climate change is affecting UK agriculture," says Professor Penfield. "It's important to be able to do this because yield is highly weather dependent in oilseed rape and it is very likely that climate change will have big consequences for the way we can use crops and the type of variety that we need to deploy."

Journal Reference:

Carmel M. O'Neill, Xiang Lu, Alexander Calderwood, Eleri H. Tudor, Philip Robinson, Rachel Wells, Richard Morris, Steven Penfield. Vernalization and Floral Transition in Autumn Drive Winter Annual Life History in Oilseed Rape. Current Biology, 2019; DOI: 10.1016/j.cub.2019.10.051

Oilseed rape heated field trials. Photo credit: Phil Robinson

RESEARCH TEAM TRACES EVOLUTION OF THE DOMESTICATED TOMATO

In a new paper, a team of evolutionary biologists and geneticists led by senior author associate professor Ana Caicedo, with first author Hamid Razifard at the University of Massachusetts Amherst, and others, report that they have identified missing links in the tomato's evolution from a wild blueberry-sized fruit in South America to the larger modern tomato of today.

The missing link that deserves more attention than it has gotten to date, they say, is one of a number of intermediate variants between the fully wild and fully domesticated tomato. Results of their genetic studies indicate that the modern cultivated tomato is most closely related to a weed-like tomato group still found in Mexico rather than to semi-domesticated intermediate types found in South America.

Razifard, a postdoctoral researcher in the Caicedo lab, says, "What's new is that we propose that about 7,000 years ago, these weedy tomatoes may have been re-domesticated into the cultivated tomato." The common cultivated tomato is the world's highest value and most widely grown vegetable crop and an important model for studying fruit development, Caicedo and colleagues point out.

In this work, part of a larger research effort supported by the National Science Foundation and led by Esther van der Knaap at the University of Georgia, the researchers say that for many years an oversimplified view of tomato domestication was thought to involve two major transitions, the first from small, wild Solanum pimpinellifolium L. (SP) to a semi-domesticated intermediate, S. lycoperiscum L. var. cerasiforme (SLC). The second was a transition from an intermediate group (SLC) to fully domesticated cultivated tomato (S. lycopersicum L. var. lycopersicum (SLL)).

Their genetic studies address the role of what they call a "historically contentious" and complex intermediate stage of tomato domestication, an essential chapter that should not be overlooked in the tomato's long journey from wildness to domestication. Details appear in an Advanced Access edition of Molecular Biology and Evolution.

Razifard and colleagues, who created a public genomic variants dataset for this study, used whole-genome sequencing of wild, intermediate and domesticated (SP, SLC, and SLL) varieties, plus population genomic analyses to reconstruct tomato domestication, focusing on evolutionary changes especially in the intermediate stages (SLC). They generated new whole-genome sequences for 166 samples, with particular attention to intermediate variants from its native range and cultivated fruit from Mexico, previously under-represented in studies.

Razifard says, "We found that SLC may have originated in Ecuador around 80,000 years ago as a wild species rather than a domesticate. It was cultivated in Peru and Ecuador by native people later to create medium-size tomato fruits. We also found that two subgroups from the intermediate group may have spread northward to Central America and Mexico possibly as a weedy companion to other crops."

"Remarkably, these northward extensions of SLC seem to have lost some of the domestication-related phenotypes present in South America. They still grow in milpas of Mexico, where people use them as food although not cultivating them intentionally," he adds. Milpas are fields where farmers plant many different crops in the same area.

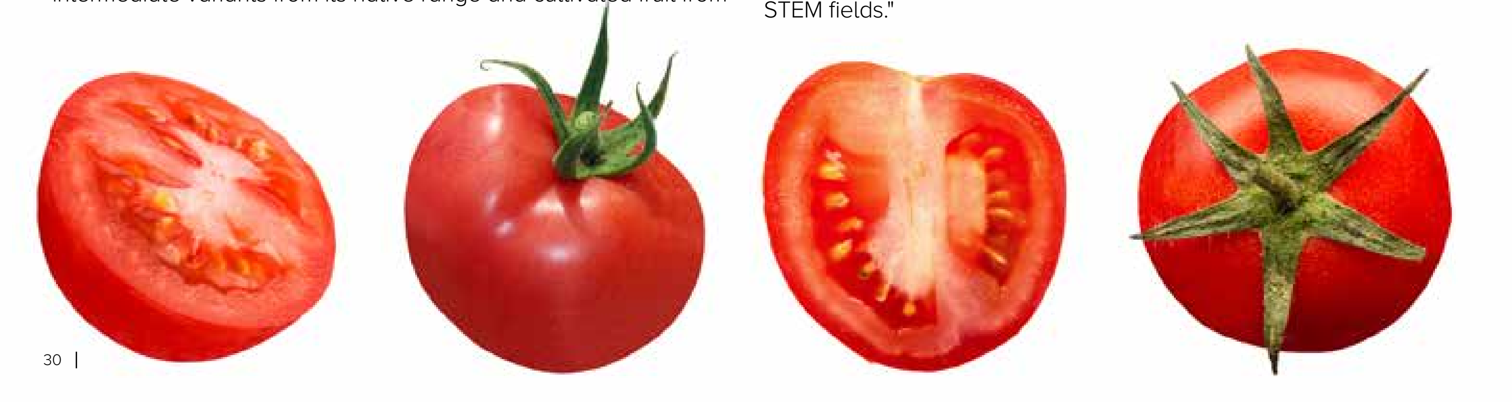
He and Caicedo note that an origin of the domestic tomato from weed-like ancestors was proposed in 1948 based on the many native names that exist for the weed-like tomato, in contrast to fewer names for the common cultivated tomato. This hypothesis was challenged by others who argued against Mexico as a centre of tomato domestication due to the absence of completely wild tomatoes there.

Razifard says, "It's still a mystery how tomatoes have moved northward. All we have is genetic evidence and no archaeological evidence because tomato seeds don't preserve well in the archeological records."

The researchers point out that exploring intermediate stages of tomato domestication has "direct implications for crop improvement." For example, they observed some signals of selection in certain intermediate populations for alleles involved in disease resistance and drought tolerance, important, Razifard says, "Such evidence is useful for finding candidate alleles that can be used for creating disease-resistant and/or drought-tolerant tomatoes." Other intermediate populations had higher beta-carotene or sugar content, attractive traits to consumers.

The evolutionary biologist says, "This is the kind of paper that Darwin would have enjoyed reading. He drew many of his insights on evolution from studying plants, especially crops. He corresponded extensively with botanists before he finalised his theory of evolution through natural selection."

A postdoctoral researcher who did much of the population genomic analyses for this project, Razifard adds that he wants to support the movement in biology against "plant blindness," the tendency to ignore the importance of plants in studying evolution as well as other subfields of biology. Also, he is from a minority Azerbaijani-speaking area of Iran and says, "This paper is special to me because it's my first one with a female-majority author list. I feel lucky to be part of a generation that is changing science, and I hope this paper serves as a model for gender equity in STEM fields."



NEW SOFT-LEAF COCKSFOOT PROVIDES QUALITY SUMMER FEED OASIS

SF Oasis is the third soft-leaf cocksfoot to be released in Australia by Seed Force. It follows the huge success of this new high-quality cocksfoot type initially launched with SF Greenly in 2008 and followed up with SF Lazuly in 2009. All three varieties have been bred by RAGT in France who are a cornerstone shareholder in Seed Force and the main supplier of their improved plant genetics marketed in Australia.

Cocksfoot has typically been used in high aluminium soils and in marginal ryegrass regions, due to its improved persistence over perennial ryegrass. It has good persistence in most soil types, handles low fertility and acid soils, but is more sensitive to long periods of waterlogging.

Because of its lower feed quality, cocksfoot has traditionally been relegated to the bottom of the list of preferred grasses to include in pasture mixes by livestock producers. But since the introduction by Seed Force of the high quality soft-leaf types, many producers have decided to use them to replace paddocks previously sown to perennial ryegrass or tall fescue.

This has resulted in the annual use of cocksfoot in Australia almost doubling over the past decade.

RAGT developed this new type of cocksfoot due to the lack of persistence of perennial ryegrass in their environment in southern France with temperatures ranging from -10° to +40°C. They focused on breeding quality into a highly persistent species with outstanding success.

“This was first witnessed by Seed Force in our early trials where we saw stock selectively graze the RAGT cocksfoots when grazing off perennial grass trials including perennial ryegrass, tall fescue, phalaris and cocksfoot” said David Gould of Seed Force.

“Seed Force has screened many cocksfoot types but has focused its efforts on the new soft leaf varieties which can deliver both high yields and much improved feed quality.

“SF Oasis is slightly later flowering than SF Lazuly and will produce much more summer feed than SF Lazuly. Where more winter feed is also required, it can be mixed with SF Jeronimo prairie grass in more summer rainfall regions such as northern NSW or with SF Maté phalaris in southern regions.

“Based on RAGT experience, Seed Force trialled different sowing rates for cocksfoot and found better quality and more successful establishment at higher seeding rates than previously used in Australia.

We now recommend sowing them at 8-12kg/ha when they are the sole grass in a mixed pasture sward,” said Mr Gould. This is still considerably cheaper per hectare than perennial ryegrass sown at 20-25kg/ha or tall fescue sown at 16-20kg/ha.

“These new soft-leaf cocksfoots can be sown at higher density rates for intensive dairy and beef operations to provide a more persistent pasture option than perennial ryegrass with no adverse animal health effects, and resistance to most plant pests such as African black beetle.”

For further information contact Seed Force at office@seedforce.com

Cocksfoot relative seasonal performance - relative to Porto = 100%

Variety	Autumn	Winter	Spring	Summer	Total	no. of trials
SF Lazuly	98	102	107	107	106	5
SF Oasis	**97**	**100**	**109**	**121**	**105**	**5**
SF Greenly	91	98	107	104	102	5
Kara	89	102	104	102	100	4
Porto	100	100	100	100	100	5
Vision	95	96	102	107	99	4
Safin	100	90	98	101	98	1
Howlong	84	104	110	78	98	1
Currie	82	101	81	94	88	1

*Varieties sown in up to five, three year replicated trials, including Armidale and Warrnambool 2012, Gloucester 2013, Penshurst 2015 and Shepparton 2016.

SF Oasis multiplication block

Cocksfoot total yield performance by site - kg DM/ha/year

	Armidale 2012		Warrnambool 2012		Gloucester 2013		Penshurst 2015		Shepparton 2016		% Porto
Variety	Total	% Porto	Total	% Porto	Total	% Porto	Total	% Porto	Total	% Porto	
SF Lazuly	5,121	100	5,260	100	13,648	124	7,459	96	15,565	107	106
SF Oasis	**5,527**	**108**	**5,451**	**104**			**8,406**	**108**	**14,683**	**101**	**105**
SF Greenly	5,037	99	5,095	97			7,033	90			102
Porto	5,102	100	5,237	100	13,455	122	7,810	100	14,485	100	100
Kara	5,159	101	5,349	102	10,984	100	6,724	86			100
Vision			5,156	98	12,329	112	7,996	102	14,395	99	99
Safin									14,234	98	98
Howlong							7,648	98			98
Currie			4,613	88							88

*trials sown at 10kg/ha. *Armidale, Warrnambool and Gloucester sites managed by Seed Force. *Penshurst site managed by AgriResults. *Shepparton site managed by Eurofins.

SF Oasis

NANOSATELLITES IMPROVE DETECTION OF EARLY-SEASON CORN NITROGEN STRESS

For corn growers, the decision of when and how much nitrogen fertiliser to apply is a perennial challenge. Scientists at the University of Illinois have shown that nanosatellites known as CubeSats can detect nitrogen stress early in the season, potentially giving farmers a chance to plan in-season nitrogen fertiliser applications and alleviate nutrient stress for crops.

"Using this technology, we can possibly see the nitrogen stress early on, before tasseling. That means farmers won't need to wait until the end of the season to see the impact of their nitrogen application decisions," says Kaiyu Guan, assistant professor in the Department of Natural Resources and Environmental Sciences at the University of Illinois, and Blue Waters professor at the National Centre for Supercomputing Applications. He is also principal investigator on a new study published in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

Being able to detect and address changes in crop nutrient status in real time is vitally important to avoid damage at critical periods and optimise yield. In general, existing satellite technology cannot achieve both high spatial resolution and high revisiting frequency (how often a given satellite comes back to the same spot above the Earth). Alternatively, drones can detect nutrient status in real time, but they usually can only cover local areas; thus, their utility is limited in scale.

CubeSats bridge the gap between existing satellite technology and drones. With more than 100 of the relatively tiny satellites currently in orbit, Guan says, "CubeSats from Planet get down to a 3-meter resolution and revisit the same location every few days. So, right now we can monitor crop nitrogen status in real time for a much broader area than drones."

Guan and his collaborators tested the capabilities of both drones and CubeSats to detect changes in corn chlorophyll content, a proxy for the plant's nitrogen status. The researchers focused on an experimental field in Central Illinois during the 2017 field season. Corn in the field was nitrogen-stressed to varying degrees due to multiple nitrogen application rates and timings, including all nitrogen applied at planting, and split applications at several developmental stages.

The analysed field was one of several in a larger study looking at nitrogen rates and timing, set up by Emerson Nafziger, professor emeritus in the Department of Crop Sciences at Illinois and co-author on the study.

"The idea was to see how much effect timing and form of nitrogen fertiliser would have on yield. This study allows an evaluation of how well the imaging could capture yield responses to nitrogen applied at different rates and times," Nafziger says.

The scientists compared images from drones and CubeSats, and their signals matched well with tissue nitrogen measurements taken from leaves in the field on a weekly basis. Both technologies were able to detect changes in chlorophyll contents with a similar degree of accuracy and at the same point in the season.

"This information generates timely and actionable insights related to nitrogen stress, and so could provide guidance for additional nitrogen application where it's needed," Guan says.

The implications go beyond optimising yield.

"The low cost of nitrogen fertiliser and high corn yield potential motivates farmers to apply extra nitrogen as 'insurance' against nitrogen deficiency that lowers yield. But applying more nitrogen than the crop requires is both a financial and environmental risk," says Yaping Cai, graduate student in Guan's research group and lead student author on the paper.

Guan adds, "A better tool for fertiliser use, enabled through new satellite technology and ecosystem modelling, could ultimately help farmers to reduce cost, increase yield, and meanwhile reduce environmental footprint for a sustainable agricultural landscape."

Research from the University of Illinois shows CubeSats, also known as nanosatellites, can detect crop nitrogen stress early in the season, allowing farmers to take action in real time. Photo credit: Planet Labs Inc

Journal Reference:

Yaping Cai, Kaiyu Guan, Emerson Nafziger, Girish Chowdhary, Bin Peng, Zhenong Jin, Shaowen Wang, Sibo Wang. Detecting In-Season Crop Nitrogen Stress of Corn for Field Trials Using UAV- and CubeSat-Based Multispectral Sensing. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2020; 1 DOI: 10.1109/JSTARS.2019.2953489

NITROGEN-FIXING GENES COULD HELP GROW MORE FOOD USING FEWER RESOURCES

Scientists have transferred a collection of genes into plant-colonising bacteria that let them draw nitrogen from the air and turn it into ammonia, a natural fertiliser.

The work could help farmers around the world use less man-made fertilisers to grow important food crops like wheat, corn, and soybeans.

The group of scientists, including two from Washington State University, published the study "Control of nitrogen fixation in bacteria that associate with cereals" late last month in Nature Microbiology.

"There's a growing interest in reducing the amount of fertiliser used in agriculture because it's expensive, has negative environmental impacts, and takes a lot of energy to make," said John Peters, Director of WSU's Institute of Biological Chemistry and a co-author on the paper. "There's a huge benefit to developing ways to increase the contributions of biological nitrogen fixation for crop production around the world."

How legumes get nitrogen

The team's research helps share a symbiotic benefit found in legume crops, which farmers have relied on for centuries to naturally enrich the soil.

Legume crops, such as chickpeas and lentils, require significantly less fertiliser than other crops, because they've developed a symbiotic relationship with bacteria that grow within their root tissues. These bacteria convert nitrogen gas to ammonia through a process called biological nitrogen fixation.

Bacteria take nitrogen from the air and convert it into ammonia for the plants, which use it for energy to grow. The plants in turn provide carbon and other nutrients to the microbes.

To work symbiotically, legumes and microbes have evolved to release signals that each can understand. The plants give off chemicals that signal to the bacteria when they need fixed nitrogen. The bacteria produce similar signals to let the plants know when they need carbon.

Fertiliser reduction

To develop a synthetic method for this symbiosis between other bacteria and crops, scientists worked to determine the groups of genes in bacteria that enable nitrogen fixing, then add those gene groups into other bacteria.

"This is just one step, although a large step, on the road to figuring out how to promote increasing contribution of biological nitrogen fixation for crop production," Peters said.

Peters and WSU are co-leads on the overall project with his colleague Philip Poole at the University of Oxford in the UK.

Reducing fertiliser requirements could have massive impacts on food availability, energy use and agriculture costs all over the world.

Fertilisers are too expensive for many farmers around the world. Without them, many nutritionally valuable foods won't grow in many areas due to nitrogen-poor soil.

"This project is aimed at increasing food production and helping feed the world," Peters said. "Transforming food production to work without nitrogen-based fertilisers could be a huge development in underdeveloped countries. Adding these microbes would be like pouring kombucha on roots."

Complex challenge

Peters' lab specialises in studying metabolic processes in bacteria, or how they create and use energy. His lab provided a blueprint for how nitrogen fixation works in different organisms. Then his co-authors, synthetic biologists at the Massachusetts Institute of Technology, can create the mechanisms that microbes and plants will need.

"This is such a complex and wide-spread challenge it really takes a large team with varied areas of expertise to solve," Peters said. "But if we succeed, the reward could be huge for the entire planet."

The project has been funded the National Science Foundation and the Biotechnology and Biological Sciences Research Council in the UK.

Journal Reference:

Min-Hyung Ryu, Jing Zhang, Tyler Toth, Devanshi Khokhani, Barney A. Geddes, Florence Mus, Amaya Garcia-Costas, John W. Peters, Philip S. Poole, Jean-Michel Ané, Christopher A. Voigt. Control of nitrogen fixation in bacteria that associate with cereals. Nature Microbiology, 2019; DOI: 10.1038/s41564-019-0631-2

GENES CONTROLLING MYCORRHIZAL COLONISATION DISCOVERED IN SOYBEAN

Like most plants, soybeans pair up with soil fungi in a symbiotic mycorrhizal relationship. In exchange for a bit of sugar, the fungus acts as an extension of the root system to pull in more phosphorus, nitrogen, micronutrients, and water than the plant could on its own.

Mycorrhizal fungi occur naturally in soil and are commercially available as soil inoculants, but new research from the University of Illinois suggests not all soybean genotypes respond the same way to their mycorrhizal relationships.

"In our study, root colonisation by one mycorrhizal species differed significantly among genotypes and ranged from 11 to 70%," says Michelle Pawlowski, postdoctoral fellow in the Department of Crop Sciences at Illinois and co-author on a new study in Theoretical and Applied Genetics.

To arrive at that finding, Pawlowski grew 350 diverse soybean genotypes in pots filled with spores of a common mycorrhizal fungus. After six weeks, she looked at the roots under a microscope to evaluate the level of colonisation.

"It was a little bit of a gamble because we didn't know much about soybean's relationship with mycorrhizae and did not know if differences in colonisation among the soybean genotypes would occur. So when we screened the soybean genotypes and found differences, it was a big relief," Pawlowski says. "That meant there was a potential to find genetic differences, too."

The process of root colonisation starts before fungal spores even germinate in the soil. Roots exude chemicals, triggering spores to germinate and grow toward the root. Once the fungus makes contact, there's a complex cascade of reactions in the plant that prevents the usual defensive attack against invading pathogens. Instead, the plant allows the fungus to enter and set up shop inside the root, where it creates tiny tree-like structures known as arbuscules; these are where the fungus and plant trade sugar and nutrients.

The study suggests there is a genetic component to root colonisation rates in soybean. To find it, Pawlowski compared the genomes of the 350 genotypes and honed in on six genomic regions associated with differing levels of colonisation in soybean.

"We were able to use all the information we have on the soybean genome and gene expression to find possible causal genes within these six regions," she says.

According to the study, the genes control chemical signals and pathways that call fungus toward roots, allow the plant to recognise mycorrhizal fungus as a "good guy," help build arbuscules, and more. "For almost every step in the colonisation process, we were finding related genes within those regions," Pawlowski says.

Knowing which genes control root colonisation could lead breeders to develop soybean cultivars with a higher affinity for mycorrhizal fungus, which could mean improved nutrient uptake, drought tolerance, and disease resistance.

"This environmentally friendly approach to improving soybean production may also help reduce the overuse of fertilisers and pesticides and promote more holistic crop production systems," says Glen Hartman, plant pathologist in the Department of Crop Sciences and crop pathologist for USDA-ARS.

Journal Reference:

Michelle L. Pawlowski, Tri D. Vuong, Babu Valliyodan, Henry T. Nguyen, Glen L. Hartman. Whole-genome resequencing identifies quantitative trait loci associated with mycorrhizal colonization of soybean. Theoretical and Applied Genetics, 2019; DOI: 10.1007/s00122-019-03471-5

PLANT RESEARCHERS EXAMINE BREAD AROMA: MODERN AND OLD WHEAT VARIETIES TASTE EQUALLY GOOD

The scientists compared taste and aroma of different breads baked in close cooperation with an artisan baker and a miller using flour from old as well as modern wheat varieties. In the journal Food Research International the research team now also describes how it can predict not only the taste but also other characteristics of bread using molecular biological approaches.

Wheat is one of the world's most important agricultural crops. In recent decades, new varieties have been cultivated. Not only are they considerably higher yielding than the older varieties but also less susceptible to pests and changing climatic conditions. In addition to that, their baking characteristics have also been improved.

In the past, the aroma (i.e. smell and taste) of bread baked from wheat flour was never important and therefore not considered during breeding, cultivation, nor was it a decisive factor in trade. One of the reasons for that is that analysing the aroma of different breads is time consuming. A comprehensive study has now examined the aroma potential of various old (i.e. released before 2000) and modern wheat varieties using molecular biology methods to predict the aroma.

The study shows how science can successfully be part of and contribute to the value chain: Several institutes at HHU and the University of Hohenheim worked on this research project alongside researchers from Zurich University of Applied Sciences, the Max Planck Institute (MPI) of Molecular Plant Physiology in Golm as well as the Beck bakery in Römerstein, Stelzenmühle mill in Bad Wurzach and the District Agricultural Office (Kreislandwirtschaftsamt) in Münsingen.

80 breads for science

To be able to compare the different aromas of a total of 40 varieties of wheat, the research team produced doughs from each variety, always using the same recipe, which were then baked. To determine whether potential differences in aroma are attributable to the respective wheat variety or to the location where that particular type of wheat was grown, two breads were baked from each variety: one with wheat grown in Gatersleben and one with wheat grown in Stuttgart-Hohenheim.

The doughs and breads were first compared based on external parameters (dough elasticity, bread size). Test persons next assessed the smell and taste of the breads following a pre-determined procedure. First the testers described in general terms how aromatic - or bland - the bread tasted. In a second step, a detailed assessment was made using the so-called 'Wäderswiler Aromarad'.

Differences in aroma depend on wheat variety and cultivation location

"I am often told that modern varieties produce blander breads than older varieties," explains Extraordinary Professor Dr Friedrich Longin from the University of Hohenheim. "We were able to prove that this is not the case. Some of both the old and the modern varieties produced very tasty breads. It is fascinating how the breads differ in taste and aroma depending on the wheat variety we used."

Master baker Heiner Beck from Römerstein baked and tasted all of the breads: "I have made and tasted a lot of breads from different wheat varieties in my time. But I'm surprised by how the breads from the different wheat varieties differ in terms of shape, aroma and even colour."

Another noteworthy finding is that the soil in which the wheat was grown has almost as much influence on the baking result and the taste of the bread as the wheat variety used. This reflects varying soil properties as well as different nutritional and mineral contents of the soils, all of which influence the composition of the wheat grains.

Molecular biological methods make it possible to predict bread quality

"A key aspect of our study is that we have found methods based on molecular markers and the metabolite profiles of the flours which can be used to predict the quality of bread," highlights Professor Dr Benjamin Stich from the Institute of Quantitative Genetics and Genomics of Plants at HHU. Together with the MPI, the HHU researchers determined the metabolic products found in the flour and carried out the statistical analysis to predict the bread characteristics.

This new method brings with it a decisive advantage for plant breeding: In order to breed a new wheat variety to be eventually put on the market, very large numbers of plants - several thousand per year - are regularly produced, all of which must be analysed to determine their properties. "It would be much too expensive and time consuming to make breads from all of those plants and to taste them all," explains Stich. With the new method, however, the grower can very quickly distinguish the plants that produce better-quality breads. This way, the number of plants to be included in a final baking test can be reduced considerably.

Journal Reference:

Friedrich Longin, Heiner Beck, Hermann Gütler, Wendelin Heilig, Michael Kleinert, Matthias Rapp, Norman Philipp, Alexander Erban, Dominik Brilhaus, Tabea Mettler-Altmann, Benjamin Stich. Aroma and quality of breads baked from old and modern wheat varieties and their prediction from genomic and flour-based metabolite profiles. Food Research International, 2019; 108748 DOI: 10.1016/j.foodres.2019.108748

NEW INSIGHTS ON THE EFFECTS OF DROUGHT AND CLIMATE VARIABILITY ON AUSTRALIAN FARMS

Australian Bureau of Agricultural and Resource Economics and Sciences' (ABARES) latest *Insights* report provides analysis on the effects of climate variability on Australian cropping and livestock farms. The report examines both short-term climate risks such as drought and longer-term shifts in climate conditions.

ABARES Senior Economist Dr Neal Hughes said that an observed shift to hotter and drier conditions over the period 2000 to 2019, relative to the period 1950 to 1999, has had a negative effect on the profits of Australian cropping and livestock farms.

"Average temperatures have increased by about one degree since 1950, while recent decades have also seen a trend toward lower winter season rainfall, particularly in the southwest and southeast of Australia," Dr Hughes said.

"Controlling for all other factors, we estimate these changes have reduced average farm profits by around 22 per cent. These effects have been most pronounced in the cropping sector, reducing average profits by 35 per cent, or $70,900 per year for a typical cropping farm.

"At a national level this amounts to an average loss in production of broadacre crops of 8% or around $1.1 billion a year.

"Although beef farms have been less affected overall, some beef farming regions have been affected more than others, particularly south-western Queensland."

Similar to past research, this study finds evidence of adaptation, with farmers getting better at managing dry conditions over time. Our results suggest that without this adaptation the effects of the post-2000 climate shift would have been considerably larger, particularity for cropping farms.

"While recent trends in rainfall have been driven at least in part by climate change, there is still significant uncertainty over long-term future rainfall. The implications of climate change projections for agriculture is an important area for further work," Dr Hughes said.

ABARES Executive Director Dr Steve Hatfield-Dodds said this study provides robust quantitative analysis of the effects of climate variability and recent shifts in seasonal conditions on Australian broadacre cropping and livestock farms.

"Analysis of this kind is complex, as you need to account for the many factors that affect farm profits, including seasonal conditions, input and output prices, technology and management practices, and farm size," Dr Hatfield-Dodds said.

"ABARES is only able to do this because of our long-term investments in high quality farm survey data and our multi-year effort to build the *farmpredict* model."

"The results from this study have important implications for the agriculture sector, particularly for how farmers and governments respond to drought risk.

"Governments face a dilemma because providing relief to farmers in times of drought risks slowing industry adjustment and innovation in the longer-term.

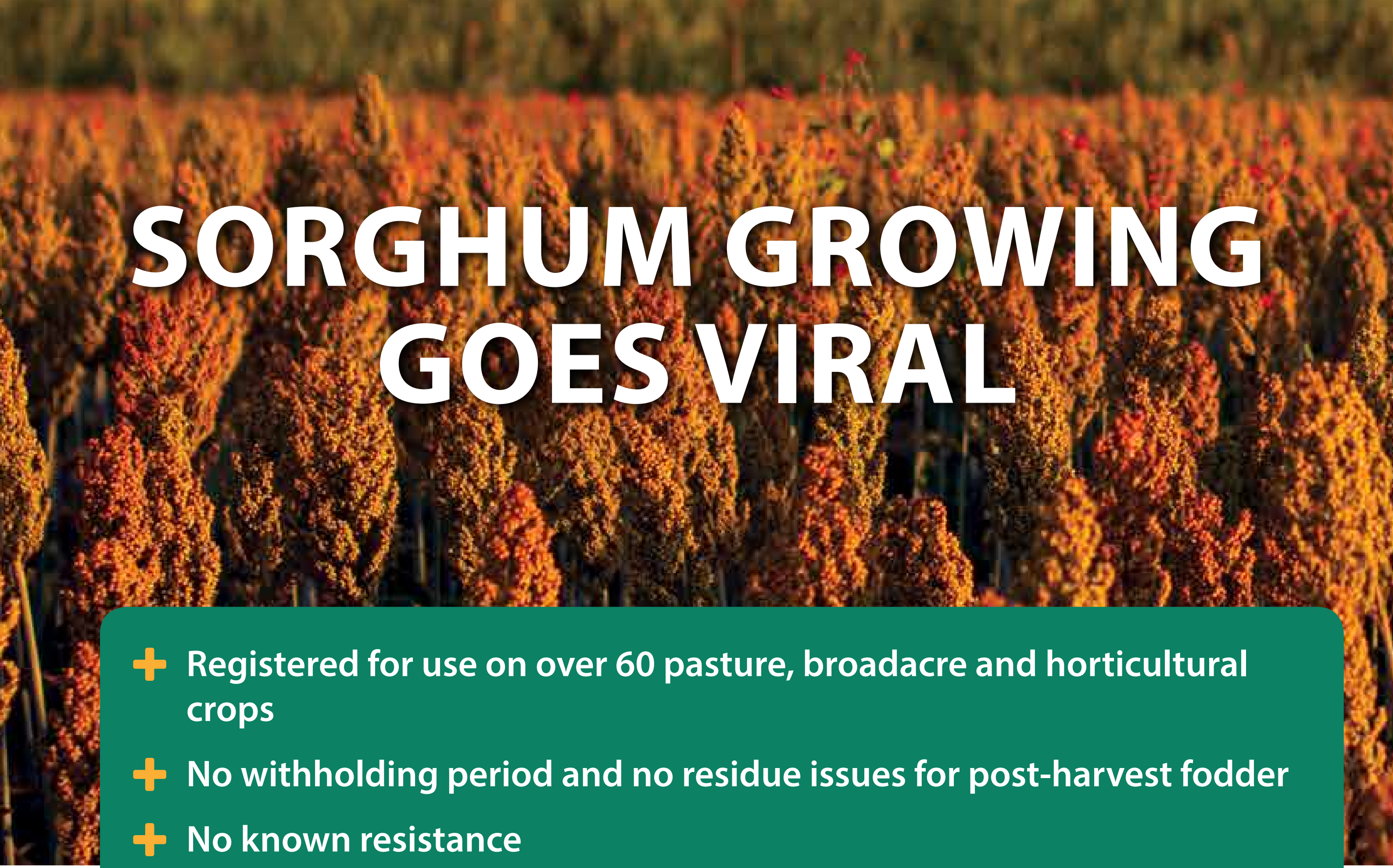
"Adjustment, change and innovation are fundamental to improving agricultural productivity; maintaining Australia's competitiveness in world markets; and providing attractive and financially sustainable opportunities for farm households.

"Supporting farm households experiencing hardship is important, but for the long term health of the sector this needs to be done in ways that promote resilience and productivity, and allow for adjustment and change.

"Key options in this regard include research and development to improve long-term farm drought resilience, including further development of weather insurance markets.

"Insurance is an important area for further research, as it could provide farmers new options for managing climate risks."

The latest ABARES Insights paper, Analysis of the effects of drought and climate variability on Australian Farms, is available at:. **www.agriculture.gov.au/abares/publications/insights/effects-of-drought-and-climate-variability-on-Australian-farms**



SORGHUM GROWING GOES VIRAL

- Registered for use on over 60 pasture, broadacre and horticultural crops
- No withholding period and no residue issues for post-harvest fodder
- No known resistance
- No impact on beneficial insects
- Over 4.5 million hectares sprayed over the last 16 years

HELICOVERPA GROWTH STAGE IDENTIFICATION

Showing the actual size of *H. armigera* larvae at a given age (days since egg hatch) when reared at 25°C.

Instar	Age (days)	Size category	Length (mm)	Actual size	ViVUS Max timing
1st	0 - 2	Very Small	1 - 3		✔✔
2nd	2 -4	Small	4 - 7		✔✔
3rd	4 - 8	Medium (small)	8 - 13		✔
4th	8 - 11	Medium (large)	14 - 23		✖
5th	11 - 14	Large	24 - 28		✖
6th	14 - 18+	Large (snake)	29 - 40+		

AgBiTech

Want more information? **www.agb**

$/HECTARE LOST* TO HELICOVERPA

ViVUS Max + Optimol + Application = $23/ha

	LARVAE / HEAD						
$/tonne	0.1	0.2	0.3	0.5	0.7	1.0	2.0
$250	$7.20	$14.40	$21.60	$36.00	$50.40	$72.00	$144.00
$300	$8.64	$17.28	$25.92	$43.20	$60.48	$86.40	$172.80
$350	$10.08	$20.16	$30.24	$50.40	$70.56	$100.80	$201.60
$400	$11.52	$23.04	$34.56	$57.60	$80.64	$115.20	$230.40

*12 heads/m, 1m row spacing. Source QDAF.

CREATE YOUR OWN THRESHOLD

NUMBER LARVAE/HEAD = $\frac{(C \times R)}{(V \times N \times 2.4)}$

WHERE

C = Cost of control ($/ha)
R = Row spacing (cm)
V = Value of crop ($/t)
N = Number of heads/m row
2.4 = weight of sorghum (grams) lost/larvae

NEW MODEL SHOWS HOW CROP ROTATION HELPS COMBAT PLANT PESTS

A new computational model shows how different patterns of crop rotation - planting different crops at different times in the same field - can impact long-term yield when the crops are threatened by plant pathogens. Maria Bargués-Ribera and Chaitanya Gokhale of the Max Planck Institute for Evolutionary Biology in Germany present the model in PLOS Computational Biology.

The continual evolution of plant pathogens poses a threat to agriculture worldwide. Previous research has shown that crop rotation can help improve pest control and soil quality. Other research shows that switching the environment in which a pathogen grows can limit its reproduction and change its evolution. However, these two concepts have been rarely studied together from an evolutionary point of view.

To better understand how crop rotation can protect against pests, Bargués-Ribera and Gokhale developed a computational model of the technique that integrates evolutionary theory. They used the model to investigate a scenario in which cash crops (grown for profit) and cover crops (grown to benefit soil) are alternated, but are affected by a pathogen that only attacks the cash crops.

The analysis identified which patterns of crop rotation maximise crop yield over multiple decades under the given scenario, revealing that regular rotations that switch every other year may not be optimal. The findings suggest that the long-term outcome of crop rotation depends on its ability to both maintain soil quality and diminish pathogen load during harvesting seasons.

"Our model is an example of how evolutionary theory can complement farmers' knowledge," Bargués-Ribera says. "In a world with ever increasing food demand, ecological and evolutionary principles can be leveraged to design strategies making agriculture efficient and sustainable."

Future research could apply the new model to specific species to assess crop rotation patterns for specific crops and their pests. The model could also be used to help study the combined effects of crop rotation and other pest control techniques, such as fungicides and use of crops that have been genetically modified for pest resistance.

Journal Reference:

Maria Bargués-Ribera, Chaitanya S. Gokhale. Eco-evolutionary agriculture: Host-pathogen dynamics in crop rotations. PLOS Computational Biology, 2020; 16 (1): e1007546 DOI: 10.1371/journal.pcbi.1007546

GENETIC MARKING DISCOVERY IMPROVES FRUIT QUALITY, BOLSTERS CLIMATE DEFENCES

Transferring genetic markers in plant breeding is a challenge, but a team of grapevine breeders and scientists at Cornell University have come up with a powerful new method that improves fruit quality and acts as a key defence against pests and a changing climate.

Plant breeders are always striving to develop new varieties that satisfy growers, producers and consumers. To do this, breeders use genetic markers to bring desirable traits from wild species into their cultivated cousins.

The team's new technique for developing genetic markers improves markers' transfer rate across grapevine species from 2% to 92%. With it, breeders worldwide can screen their collections and find out immediately which vines have the traits they want - regardless of what varieties they are, where they came from or which species their parents were.

"This new marker development strategy goes well beyond grapes," said co-author Bruce Reisch, professor of horticulture in the College of Agriculture and Life Sciences, and leader of Cornell's Grapevine Breeding and Genetics Program. "It's applicable for breeding and genetic studies across different grape breeding programs, plant species and other diverse organisms."

To create the genetic markers, the research team used new automated DNA sequencing technology to create a "core genome" for grapevines, matching important regions shared between 10 species' genomes. Using powerful new genetic mapping technology, they targeted those regions to develop robust DNA markers.

This breakthrough in translating the grapevine genome into a common language for breeders is central to the mission of VitisGen2, the second iteration of a multi-institution research project from which the new marker development strategy emerged.

"This is game-changing work - and it's only the beginning," said Donnell Brown, president of the National Grape Research Alliance, an industry-led nonprofit representing the research interests of wine, juice, raisin and table grapes. "From here, we can greatly accelerate the genetic exploration that will help us improve fruit and production quality and, ultimately, respond to the threats of pests and diseases, a changing climate and more."

Journal Reference:

Zou, C., Karn, A., Reisch, B. et al. Haplotyping the Vitis collinear core genome with rhAmpSeq improves marker transferability in a diverse genus. Nat Commun 11, 413 (2020). https://doi.org/10.1038/s41467-019-14280-1

INSECT BITES AND WARMER CLIMATE MEANS DOUBLE-TROUBLE FOR PLANTS

Recent models are telling us that, as our climate warms up, herbivores and pests will cause increased damage to agricultural crops. One study predicted that crop yield lost to insects increases 10 to 25 percent for every 1 degree Celsius increase.

Michigan State University scientists think that these models are incomplete and that we may be underestimating the losses. A new study shows that infested tomato plants, in their efforts to fight off caterpillars, don't adapt well to rising temperatures. This double-edged sword worsens their productivity.

According to the study, two factors are at play. The first is rising temperatures. Insect metabolism speeds up with heat and they eat more. Also, warmer temperatures could open up a wider range of hospitable habitats to insects.

Second, and this is what current models ignore, is how the infested plants react to the heat.

"We know that there are constraints that prevent plants from dealing with two stresses simultaneously," said Gregg Howe, University Distinguished Professor at the MSU-DOE Plant Research Laboratory. "In this case, little is known about how plants cope with increased temperature and insect attack at the same time, so we wanted to try and fill that gap."

Plants have systems to deal with different threats. Caterpillar attack? There is a system for that. When a caterpillar takes a bite off a leaf, the plant produces a hormone, called Jasmonate, or JA. JA tells the plant to quickly produce defence compounds to thwart the caterpillar.

Temperatures too hot? Overheated crops have another bag of tricks to cool themselves down. Obviously, they can't make a run for the inviting shade under a tree. They lift their leaves away from the hot soil. They also "sweat" by opening their stomata - similar to skin pores - so that water can evaporate to cool the leaves.

Nathan Havko, a postdoctoral researcher in the Howe lab, had a breakthrough when he grew tomato plants in hot growth chambers, which are kept at 38 degrees Celsius. He also let hungry caterpillars loose on them.

"I was shocked when I opened the doors to the growth chamber where the two sets of plants were growing at 'normal' and 'high' temperatures," Howe said. "The caterpillars in the warmer space were much bigger; they had almost wiped the plant out."

"When temperatures are higher, a wounded tomato plant cranks out even more JA, leading to a stronger defence response," Havko said. "Somehow, that does not deter the caterpillars. Moreover, we found that JA blocks the plant's ability to cool itself down, it can't lift its leaves or sweat."

Perhaps, the plants close their pores to stop losing water from the wounded sites, but they end up suffering the equivalent of a heat stroke. It's even possible that the caterpillars are crafty and do extra damage to keep the leaf pores closed and leaf temperatures elevated, which will speed up the insect's growth and development.

And, there are consequences.

"We see photosynthesis, which is how crops produce biomass, is strongly impaired in these plants," Havko said. "The resources to produce biomass are there, but somehow they aren't used properly and crop productivity decreases."

There are many open questions to be resolved but, as of right now, the study suggests that when global temperatures rise, plants might have too many balls to juggle.

"I think we have yet to appreciate the unexpected tradeoffs between defence responses and plant productivity, especially when other types of environmental stress are present," Howe said. "Turning on the defence response may do more harm than good if the plants face high temperatures or other stresses."

The study is published in the journal Proceedings of the National Academy of Sciences. The research team from the Howe lab includes Michael Das, George Kapali, Nathan Havko and Gregg Howe. Research on photosynthesis was done with the support of Alan McClain and Thomas Sharkey from the Sharkey lab.

Journal Reference:

Qiang Guo, Yuki Yoshida, Ian T. Major, Kun Wang, Koichi Sugimoto, George Kapali, Nathan E. Havko, Christoph Benning, Gregg A. Howe. JAZ repressors of metabolic defense promote growth and reproductive fitness inArabidopsis. Proceedings of the National Academy of Sciences, 2018; 115 (45): E10768 DOI: 10.1073/pnas.1811828115

A new study shows that infested tomato plants, in their efforts to fight off caterpillars, don't adapt well to rising temperatures. This double-edged sword worsens their productivity. Photo credit: Courtesy of MSU

MICROSCOPIC PARTNERS COULD HELP PLANTS SURVIVE STRESSFUL ENVIRONMENTS

Tiny, symbiotic fungi play an outsized role in helping plants survive stresses like drought and extreme temperatures, which could help feed a planet experiencing climate change, report scientists at Washington State University.

Recently published in the journal Functional Ecology, the discovery by plant-microbe biologist Stephanie Porter and plant pathologist Maren Friesen sheds light on how microbe partners can help sustainably grow a wide variety of crops.

Tiny partners in plant survival

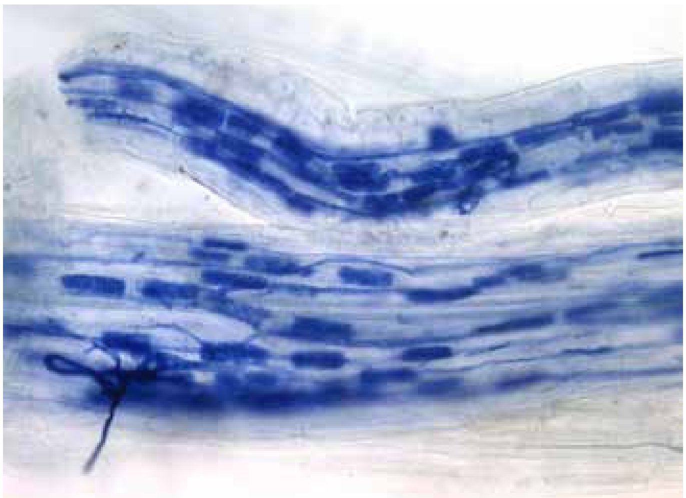
While some microscopic fungi and bacteria cause disease, others live in harmony with plants, collecting water and nutrients in exchange for carbohydrates, or changing plants' internal and external environment in ways that help plants grow.

These benefits help plants tolerate stresses that come from their environment. Dubbed abiotic stresses, challenges such as drought, extreme temperatures, and poor, toxic, or saline soils are among the leading causes of crop loss and decreasing farm productivity.

"Plants' abilities to tolerate stress are impacted by the bacteria and fungi that live on or inside them and make up the plant microbiome," said Porter, assistant professor in the School of Biological Sciences. "Just like how microbes in our digestive system help keep us healthy, microbes play an incredibly important role in plant health."

Setting out to measure how beneficial microbes affect plants under both normal conditions and stress, Porter and Friesen reviewed 89 research experiments ranging from common Northwest food crops to wild species.

Working with colleagues at Michigan State University and WSU, they compared five different classes of symbiotic bacteria and fungi that live on, in, and around plant roots, under stresses that included fungal diseases, grazing by animals and microscopic worms, heavy metal contamination, and drought, cold, and saline soils. Then, they tallied the effect on plant growth, biomass and yield.



Blue-stained filaments of arbuscular mycorrhizal fungus, which lives in symbiosis with plants, inhabit plant roots in this microscope image. Photo credit: Ashley Finnestad, T.E. Cheeke Lab, WSU.

Results showed that while beneficial bacteria are more helpful in normal conditions, symbiotic fungi provide added benefits during crises.

"Stress makes these fungi even more important to plants, which we think is really interesting," said Friesen, assistant professor in the Department of Plant Pathology.

Particularly beneficial were arbuscular mycorrhizal fungi, which colonise plant roots, provide water, and enhance uptake of nitrogen, phosphorus, and other micronutrients in the soil.

"Should growers want to foster the plant microbiome for stress resistance, our study suggests they should really focus on fungi," Porter said. "These beneficial microbes could be the key to helping us grow more food in the coming decades."

A greener solution to stress

With earth's population predicted to top 9 billion by 2050, scientists predict that current crop yields will need to double.

"As we expand where we grow crops, we're using marginal areas that are more stressful for plants," Porter said. "And as our climate changes, that creates stress for plants.

"Maren and I wanted to be forward-looking," she added. "We wanted to find evidence of how we can best use beneficial microbes to mitigate the stresses that we know are coming."

Microbes offer a more sustainable tool for stress tolerance than applying hormones or chemicals, noted Friesen.

"Farmers are now having challenges with pathogens no longer responding to chemical treatments," she said. "There's already a lot of interest in scientific and industry circles in identifying and harnessing microbial solutions to agricultural problems. This study gives us ideas about where to look."

Journal Reference:

Stephanie S. Porter, Roxanne Bantay, Colleen A. Friel, Aaron Garoutte, Kristi Gdanetz, Kathleen Ibarreta, Bethany M. Moore, Prateek Shetty, Eleanor Siler, Maren L. Friesen. Beneficial microbes ameliorate abiotic and biotic sources of stress on plants. Functional Ecology, 2020; DOI: 10.1111/1365-2435.13499

INSECTICIDES ARE BECOMING MORE TOXIC TO HONEY BEES

During the past 20 years, insecticides applied to U.S. agricultural landscapes have become significantly more toxic - over 120-fold in some midwestern states - to honey bees when ingested, according to a team of researchers, who identified rising neonicotinoid seed treatments in corn and soy as the primary driver of this change. The study is the first to characterise the geographic patterns of insecticide toxicity to bees and reveal specific areas of the country where mitigation and conservation efforts could be focused.

According to Christina Grozinger, Distinguished Professor of Entomology and director of the Centre for Pollinator Research, Penn State, this toxicity has increased during the same period in which widespread decline in populations of pollinators and other insects have been documented.

"Insecticides are important for managing insects that damage crops, but they can also affect other insect species, such as bees and other pollinators, in the surrounding landscape," she said. "It is problematic that there is such a dramatic increase in the total insecticide toxicity at a time when there is also so much concern about declines in populations of pollinating insects, which also play a very critical role in agricultural production."

The researchers, led by Maggie Douglas, assistant professor of environmental studies, Dickinson College, and former postdoctoral fellow, Penn State, integrated several public databases - including insecticide use data from the U.S. Geological Survey, toxicity data from the Environmental Protection Agency, and crop acreage data from the U.S. Department of Agriculture - to generate county-level annual estimates of honey bee "toxic load" for insecticides applied between 1997 and 2012. The team defined toxic load as the number of lethal doses to bees from all insecticides applied to cropland in each county.

The researchers generated separate estimates for contact-based toxic loads, such as when a bee is sprayed directly, and oral-based toxic loads, such as when a bee ingests the pollen or nectar of a plant that has recently been treated. They generated a map of predicted insecticide toxic load at the county level. Their results appeared in late January in Scientific Reports.

The team found that the pounds of insecticides applied decreased in most counties from 1997 to 2012, while contact-based bee toxic load remained relatively steady. In contrast, oral-based bee toxic load increased by 9-fold, on average, across the U.S. This pattern varied by region, with the greatest increase - 121-fold - seen in the Heartland, which the U.S. Department of Agriculture defines as all of Iowa, Illinois and Indiana; most of Missouri; and part of Minnesota, Ohio, Kentucky, Nebraska and South Dakota. The Northern Great Plains had the second highest increase at 53-fold. This region includes all of North Dakota and part of South Dakota, Nebraska, Colorado, Wyoming, Montana and Minnesota.

"This dramatic increase in oral-based toxic load is connected to a shift toward widespread use of neonicotinoid insecticides, which are unusually toxic to bees when they are ingested," said Douglas.

The most widely used family of insecticides in the world, neonicotinoids are commonly used as seed coatings in crops, such as corn and soybean. Some of the insecticide is taken up by the growing plants and distributed throughout their tissues, while the rest is lost to the environment.

"Several studies have shown that these seed treatments have negligible benefits for most crops in most regions," said Grozinger. "Unfortunately, growers often don't have the option to purchase seeds without these treatments; they don't have choices in how to manage their crops."

The researchers suggest that the common method of evaluating insecticide use trends in terms of pounds of insecticides applied does not give an accurate picture of environmental impact.

"The indicator we use - bee toxic load - can be considered as an alternative indicator in cases where impacts to bees and other non-target insects is a concern," said Douglas. "This is particularly relevant given that many states have recently developed 'Pollinator Protection Plans' to monitor and address pollinator declines. Ultimately, our work helps to identify geographic areas where in-depth risk assessment and insecticide mitigation and conservation efforts could be focused."

"It is important to note that the calculation of bee toxic load provides information about the total toxicity of insecticides applied to a landscape," said Grozinger. "It does not calculate how much of that insecticide actually comes in contact with bees, or how long the insecticide lasts before it is broken down. Future studies are needed to determine how toxic load associates with changes in populations of bees and other insects."

This research is part of a larger project to investigate the various stressors impacting pollinator populations across the United States. One tool created within this research project is Beescape, which allows users to explore the stressors affecting bees in their own communities.

Journal Reference:

Margaret R. Douglas, Douglas B. Sponsler, Eric V. Lonsdorf, Christina M. Grozinger. County-level analysis reveals a rapidly shifting landscape of insecticide hazard to honey bees (Apis mellifera) on US farmland. Scientific Reports, 2020; 10 (1) DOI: 10.1038/s41598-019-57225-w

FEEDING THE WORLD WITHOUT WRECKING THE PLANET IS POSSIBLE

"When looking at the status of planet Earth and the influence of current global agriculture practices upon it, there's a lot of reason to worry, but also reason for hope - if we see decisive actions very soon," Dieter Gerten says, lead author from PIK and professor at Humboldt University of Berlin.

"Currently, almost half of global food production relies on crossing Earth's environmental boundaries. We appropriate too much land for crops and livestock, fertilise too heavily and irrigate too extensively. To solve this issue in the face of a still growing world population, we collectively need to rethink how to produce food. Excitingly, our research shows that such transformations will make it possible to provide enough food for up to 10 billion people."

The researchers ask the question how many people could be fed while keeping a strict standard of environmental sustainability worldwide. These environmental capacities are defined in terms of a set of planetary boundaries - scientifically defined targets of maximum allowed human interference with processes that regulate the state of the planet. The present study accounts for four of nine boundaries most relevant for agriculture: Biosphere integrity (keeping biodiversity and ecosystems intact), land-system change, freshwater use, and nitrogen flows. Based on a sophisticated simulation model, the impacts of food on these boundaries are scrutinised at a level of spatial and process detail never accomplished before, and moreover aggregated to the entire planet. This analysis demonstrates where and how many boundaries are being violated by current food production and in which ways this development could be reverted through adopting more sustainable forms of agriculture.

Globally differentiated picture: In some regions, less would be more

The encouraging result is that, in theory, 10 billion people can be fed without compromising the Earth system. This leads to very interesting conclusions, as Johan Rockström, director of PIK points out "We find that currently, agriculture in many regions is using too much water, land, or fertiliser. Production in these regions thus needs to be brought into line with environmental sustainability. Yet, there are huge opportunities to sustainably increase agricultural production in these and other regions. This goes for large parts of Sub-Saharan Africa, for example, where more efficient water and nutrient management could strongly improve yields."

As a positive side effect, sustainable agriculture can increase overall climate resilience while also limiting global warming. In other places, however, farming is so far off local and Earth's boundaries that even more sustainable systems could not completely balance the pressure on the environment, such as in parts of the Middle East, Indonesia, and to some extent in Central Europe. Even after recalibrating agricultural production, international trade will remain a key element of a sustainably fed world.

Hard to chew: Dietary changes needed

Importantly, there is the consumers' end, too. Large-scale dietary shifts seem to be inevitable for turning the tide to a sustainable food system. For example, regarding China's currently rising meat consumption, parts of animal proteins would need to be substituted by more legumes and other vegetables. "Changes like this might seem hard to chew at first. But in the long run, dietary changes towards a more sustainable mix on your plate will not only benefit the planet, but also people's health," adds Vera Heck from PIK. Another crucial factor is reducing food loss. In line with scenarios adopted in the present study, the most recent IPCC Special Report on land use found that currently, up to 30 percent of all food produced is lost to waste. "This situation clearly calls for resolute policy measures to set incentives right on both the producers' and consumers' ends," Heck further lays out.

Perhaps the most sensitive and challenging implication of the study relates to land. "Anything involving land tends to be complex and contested in practice because people's livelihoods and outlook depend on it. Transitioning to more sustainable land use and management is therefore a demanding challenge to policy-making. Key to success is that the regions affected need to see clear benefits for their development. Then there is a real chance that support for new directions will grow fast enough for stabilising the Earth system," says Wolfgang Lucht, co-chair for Earth System Analysis at PIK and co-author of the study.

Journal Reference:

Dieter Gerten, Vera Heck, Jonas Jägermeyr, Benjamin Leon Bodirsky, Ingo Fetzer, Mika Jalava, Matti Kummu, Wolfgang Lucht, Johan Rockström, Sibyll Schaphoff, Hans Joachim Schellnhuber. Feeding ten billion people is possible within four terrestrial planetary boundaries. Nature Sustainability, 2020; DOI: 10.1038/s41893-019-0465-1

LEADING RHIZOBIA BRANDS AND KNOWLEDGE TO GROW BIOLOGICAL BUSINESS

For 20 years, New Edge Microbials has specialised in the production of nitrogen-fixing legume inoculants. Our products cover all major crop types grown from strains held by the Australian Inoculants Research Group (AIRG). New Edge Microbials also supplies Rhizobium cultures for several smaller, specialised crops and pasture varieties. Inoculation is a cost-effective method of converting atmospheric gaseous nitrogen into a form usable by plants and they are freely available in a range of forms.

New Edge Microbials Director, Daniel Zinga, states that their business provides support of this extensive range of legume-rhizobia strains with the highest quality legume inoculants formulations. “These formulations are not always available across all the individual strains, however, so always refer to the NEM legume inoculant group chart when selecting the correct rhizobia strain and formulation required”, he said.

Nodule N™ - Australia’s tried and true Rhizobium legume inoculant in peat, is commonly used in a slurry, directly applied to the seed and can also be used in the water injection method directly into the seeding furrow. Containing high levels of humic material, Nodule N provides moisture and nutrients to help the rhizobium bacteria become established.

“SARDI trial results indicate that to optimise nodulation when dry sowing, rhizobia can be applied in high numbers at sowing by increasing the rate of inoculant applied. For example, twice the recommended rate of peat”, says Daniel.

The water soluble EasyRhiz™ - a freeze dried vial of concentrated inoculant, allows farmers to place rhizobium microbes right where they are needed. It is ideally suited for liquid injection systems and/or traditional slurry inoculation methods. EasyRhiz is a convenient formulation of legume inoculant that is easy to transport, mixes well with water, stays in suspension and passes through the finest spray nozzles.

Liqui-Rhiz™ - a liquid formulation - contains Bradyrhizobium sp, selected specifically for its symbiotic benefit and efficiency of fixing nitrogen in soybean crops and can fix as much at 300kg/ha of nitrogen. The significantly higher concentration of rhizobium available in liquid soybean inoculant can achieve superior early nodulation. Soybean liquid inoculant can be applied either to seed or applied directly via ‘liquid injection’ to the soil in the seeding furrow.

“Granule development is underway within the business with extensive reviews of formulations and carriers. Plus, field trials will continue this season with product development stock to be available for the 2020 season.

“The introduction of granular formulation has simplified the delivery of rhizobia to legumes. The formulation has been adopted as an alternative to the traditional peat slurry ‘on seed’ method, which can provide greater flexibility and a practical solution in sowing operations. The physical separation of rhizobia from the seed, allows insecticides and pesticides, that are considered hostile toward rhizobia survival, to be applied to the seed”.

With local manufacturing, New Edge Microbials’ development of a granular product is seen as a vital alternative for Australian growers who are craving to ease the labour burden at planting, opening the sowing window for pulses with granules to improve capacity to survive in dry sowing conditions.

“Our business partners and farmers can be assured they are receiving the highest quality legume inoculants and inoculant

"Our microbial library continues to grow, and we encourage our business partners and farmers to engage with our team to develop the best approach to suit their specific farming system". Daniel Zinga

Failed Hicoat LHS vs Hicoat sown on a patch with soybean history

Faba Legume Roots close up

products containing correct strain and numbers of rhizobia for effective root-nodulation to take place", says Daniel.

New Edge Microbials quality assurance is supported by being a signatory to the Australian Inoculant research group (AIRG) Code of practice. Business participants who are a signatory to the code with NSW DPI, may display on their product a quality 'green tick' logo. The green tick is the logo of the AIRG and is a registered trademark of NSW DPI.

Interest in biological farming techniques continues to establish in Australian agriculture as producers search for methods to reduce their reliance on traditional chemical and fertiliser applications.

"Our established business is poised to meet this rapidly growing segment to support and supply biologicals that will assist agriculture by utilising our experience of fermentation, which is scale-ready. Driven by our knowledge of microbial performance for product development, crops will be more resistant to abiotic crop stresses, such as heat, drought, and climate change effects, while increasing crop health and yields", he said.

New Edge Microbials' product category, 'Plant nutrient uptake', has several beneficial microbial strains for a variety of applications related to improving plant nutrient uptake. These can be seed-applied or as an in-furrow treatment. Specific strain isolates include: Bacillus, Trichoderma, Azospirillum, Pseudomonas & Streptomyces. These strains can be supplied in freeze dried or liquid formulation.

"Our microbial library continues to grow, and we encourage our business partners and farmers to engage with our team to develop the best approach to suit their specific farming system".

GETTING TO THE ROOT OF PLANT SURVIVAL

FINDINGS COULD HELP SCIENTISTS CONTROL ROOT EMERGENCE AND BATTLE DRY CONDITIONS BROUGHT ON BY CLIMATE CHANGE

When facing a volatile climate, nature searches for a way to survive. For plants, that often means spreading new roots deeper and wider in search of water, particularly in times of drought. While scientists have recognised the process of root emergence for decades, how intercellular communication may drive this phenomenon was previously unknown.

Now, Jung-Youn Lee, University of Delaware professor of plant molecular and cellular biology, and Ross Sager, a former graduate student and UD alumnus, have identified hormones and proteins that interact to regulate the root emergence process.

Their team's first-of-its-kind study was recently published in the journal Nature Communications.

Plant communication

Plasmodesmata function as the main communication pathways within a plant, sending messages through virtually every cell from root to shoot. Often, each cell receives the new information and this intercellular communication is critical to the plant's survival.

"Picture a brick wall and that's what the surface of a root looks like. Each brick is an individual cell. The cement binding them is the cell wall. Unlike a brick wall, however, plant cells are also linked by fine thread-like nano-tunnels called plasmodesmata, through which cells transmit various signals and messages to share. Obviously, when the channels are closed off, no signals would be transmitted, isolating the cells from getting any messages from their neighbours," said Lee.

When lateral roots, or secondary roots, need to emerge from the primary root, the cells directly above the emerging root must separate from each other to make way. To accomplish this, the plasmodesmata connecting those soon-to-split cells must be closed off so that the new root emerges at a normal speed. If the plasmodesmata remain open, the new root emerges at a faster speed which may compromise the vitality or immunity of the root and cause the plant to be vulnerable to threats from various soil pathogens.

Root emergence regulation

While studying the expression pattern of PDLP5 - a protein associated with plasmodesmata - in Arabidopsis seedlings, Sager noticed an unexpected pattern in the roots. Closer examination revealed that the pattern involved cells that were overlying emerging lateral roots.

"I had designed this particular experiment to study PDLP5 expression in the young seedling leaves," said Sager, "but when I noticed that pattern in the roots and showed it to Dr. Lee, we agreed it was unique for a plasmodesmal protein and warranted further research."

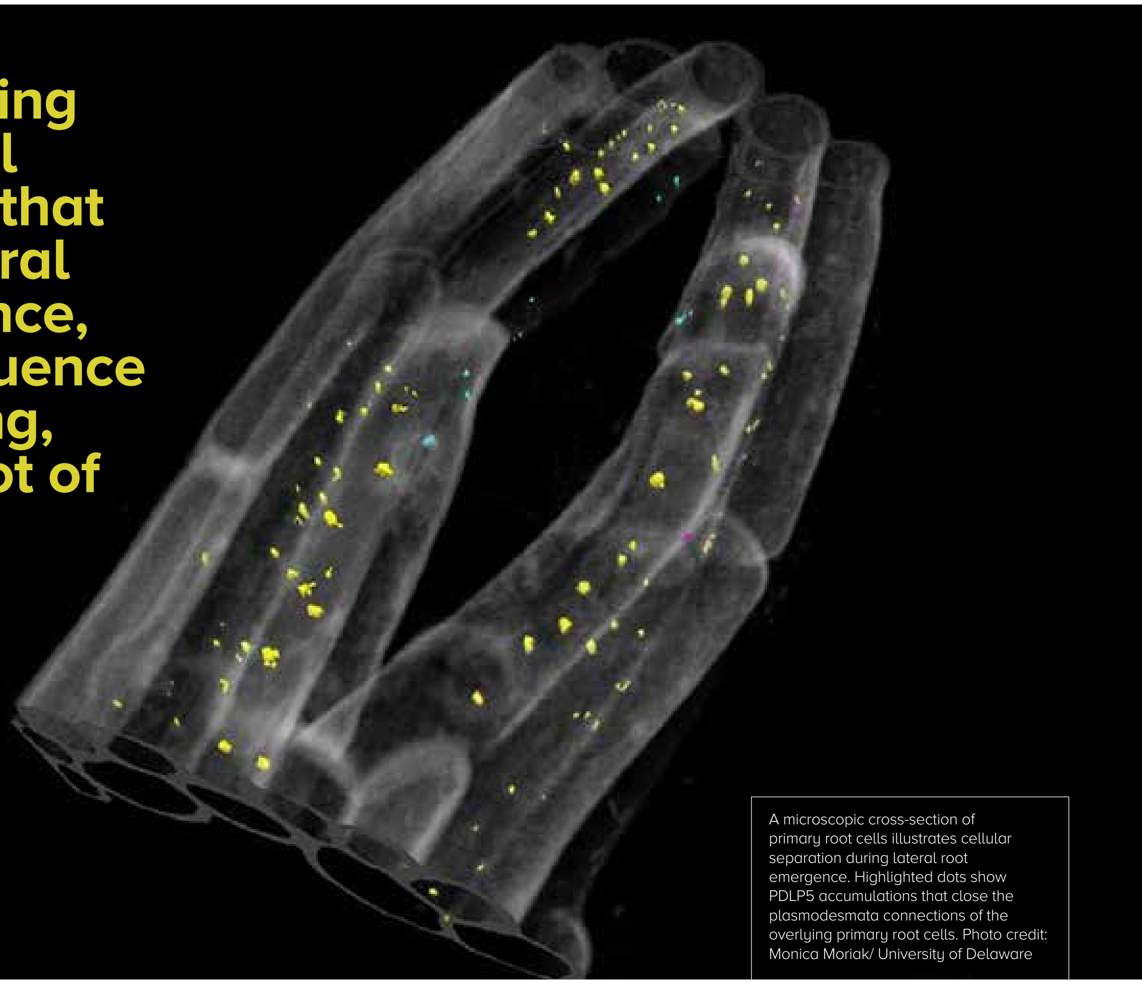
Pursuing this intriguing pattern led Sager and Lee to discover a critical feedback loop that seems to allow small subsets of cells to regulate their plasmodesmata connections via PDLP5, allowing them to operate independently from the rest of the plant as the lateral root develops and emerges.

When auxin, the hormone that drives the formation of the lateral root tissue, signals to the plant cells that a new root is ready to form and emerge, it also tells those cells directly overlying the newly forming root to start producing PDLP5. As this protein accumulates, Sager and Lee posit that it closes the plasmodesmata connections, ensuring that these overlying cell layers are able to operate autonomously as they separate and allow the lateral root to pass through. When the process is complete, this research suggests that PDLP5 sends a return signal that represses auxin. After the new lateral root is fully emerged, the overlying cells reopen the plasmodesmata connections, effectively reconnecting to the plant communication pathways.

"While our research suggests that plasmodesmal closure in these cells is important for lateral root emergence, we don't actually

"Understanding the individual components that regulate lateral root emergence, both the sequence and the timing, opens up a lot of opportunity"

Jung-Youn Lee



A microscopic cross-section of primary root cells illustrates cellular separation during lateral root emergence. Highlighted dots show PDLP5 accumulations that close the plasmodesmata connections of the overlying primary root cells. Photo credit: Monica Moriak/ University of Delaware

know why yet," said Sager. "Does it alter the movement of key signalling components? Prevent harmful factors in the soil from entering the cell? I look forward to other scientists using our paper as a stepping stone to answer these questions."

Opportunity because of climate change

According to Lee, this signalling mechanism and feedback loop could pave the way for groundbreaking advances in plant and crop engineering.

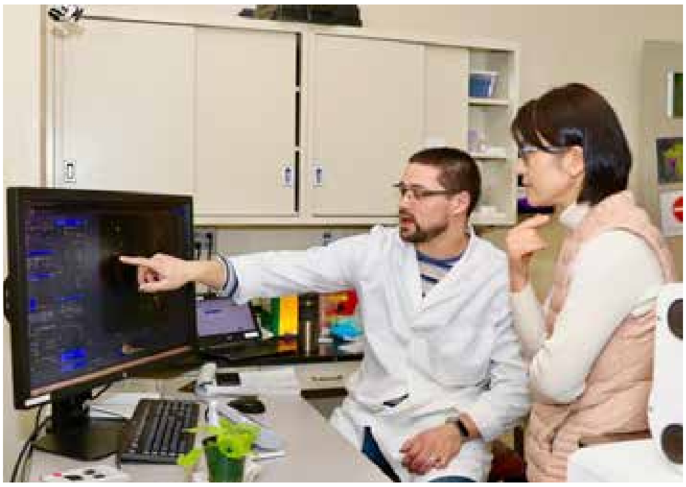
"Understanding the individual components that regulate lateral root emergence, both the sequence and the timing, opens up a lot of opportunity," said Lee. "When there's a drought, plants and crops die because they can't find water quickly and efficiently. One of the mechanisms they use to survive drought is to put down more roots. With this discovery of the communication loop regulating lateral roots, we may eventually be able to control when and how many additional roots a plant can form."

Crops are often adapted to the environments in which they grow. But as climate change continues to make patterns more erratic, like extending dry seasons, plant adaptability will be vital to agricultural production and ecosystem survival. Roots may need to grow at different rates or different times. Lee notes that information on engineering crops to sprout roots like this doesn't yet exist, but identifying specifically how roots emerge is an important first step.

Exploring plant communication at the molecular and cellular levels continues to be the primary focus in Lee's laboratory at the Delaware Biotechnology Institute. Following this study and previous research on cellular communication, Lee and her team are now further exploring PDLP5 and similar proteins.

"PDLP5 has been our lucky break," noted Lee. "That protein opened up so many new paths for us and also for newcomers to explore. It also became a fantastic bridge connecting us to great research collaborators, including Dr. Malcolm Bennett at the University of Nottingham, the world's leading expert on root branching."

"What's next?" Lee continued. "We are currently conducting interdisciplinary research with Dr. Li Liao in computational science and engineering at UD to discover how PDLP5 and its family members find and anchor to plasmodesmata, which is generously funded by the National Science Foundation. We are already so amazed by the path that PDLP5 is leading us."



University of Delaware Professor Jung-Youn Lee (right) and postdoctoral researcher Gabriel Robles Luna discuss lateral root structures. Lee's research team continues to study the role of plasmodesmal proteins in plant communication. Photo credit: Monica Moriak/ University of Delaware

Journal Reference:

Sager, R., Wang, X., Hill, K. et al. Auxin-dependent control of a plasmodesmal regulator creates a negative feedback loop modulating lateral root emergence. Nat Commun 11, 364 (2020). https://doi.org/10.1038/s41467-019-14226-7

PLANTS MANIPULATE THEIR SOIL ENVIRONMENT TO ASSURE A STEADY SUPPLY OF NUTRIENTS

The next time you're thinking about whether to cook dinner or order a pizza for delivery, think of this: Plants have been doing pretty much the same thing for eons.

Researchers in Rice University's Systems, Synthetic and Physical Biology program detailed how plants have evolved to call for nutrients, using convenient bacteria as a delivery service.

Their open-access report in Science Advances looks at how plants read the local environment and, when necessary, make and release molecules called flavonoids. These molecules attract microbes that infect the plants and form nitrogen nodules - where food is generated - at their roots.

When nitrogen is present and available, plants don't need to order in. Their ability to sense the presence of a nearby slow-release nitrogen source, organic carbon, is the key.

"It's a gorgeous example of evolution: Plants change a couple of (oxygen/hydrogen) groups here and there in the flavonoid, and this allows them to use soil conditions to control which microbes they talk to," said Rice biogeochemist Caroline Masiello, a co-author of the study.

The Rice team, in collaboration with researchers at Cornell University, specifically analysed how flavonoids mediate interactions between plants and microbes depending on the presence of abiotic (nonliving) carbon. Their experiments revealed, to their surprise, that an excess of dissolved - rather than solid - carbon in soil effectively quenches flavonoid signals.

Understanding how carbon in soil affects these signals may provide a way to engineer beneficial interactions between plants and microbes and to design effective soil amendments (additives that balance deficiencies in soil), according to the researchers. Plants use flavonoids as a defence mechanism against root pathogens and could manipulate the organic carbon they produce to interfere with signalling between microbes and other plants that compete for the same nutrients.

Overall, they showed that higher organic carbon levels in soil repressed flavonoid signals by up to 98%. In one set of experiments, interrupting the signals between legume plants and microbes sharply cut the formation of nitrogen nodules.

Rice graduate student Ilenne Del Valle began the study when she became interested in the subtle differences between the thousands of flavonoids and how they influence connections between plants and microbes in soil.

"We had studied how different soil amendments change how microbes communicate with one another," said Del Valle, co-lead author of the paper with former Cornell postdoctoral associate Tara Webster. "The next question was whether this was happening when the microbes communicate with plants.

"We knew that plants modulate symbiosis with microbes through flavonoid molecules," she said. "So we wanted to learn how flavonoids interact with soil amendments used for different purposes in agriculture."

Because she counts two Rice professors - Masiello and synthetic biologist Joff Silberg - as her advisers, she had access to tools from both disciplines to discover the mechanisms behind those subtleties.

"We came into this thinking there was going to be a big effect from biochar," Silberg said. "Biochar is charcoal made for agricultural amendment, and it is well-known to affect microbe-microbe signals. It has a lot of surface area, and flavonoids look sticky, too. People thought they would stick to the biochar.

"They didn't. Instead, we found that dissolved carbon moving through water in the soil was affecting signals," he said. "It was very different from all of our expectations."

The Rice and Cornell team set up experiments with soils from meadows, farms and forests and then mixed in three slightly different flavonoids: naringenin, quercetin and luteolin.

They found the most dramatic effects when dissolved carbons derived from plant matter or compost were present. Plants employ naringenin, a variant of the flavonoid that gives grapefruit its bitter taste, and luteolin, expressed by leaves and many vegetables, to call for microbial nitrogen fixation. These were most curtailed in their ability to find microbes. Quercetin, also found in foods like kale and red onions and used for defense against pests, did not suffer the same fate.

Masiello noted there's a cost for plants to connect with microbes in the soil.

"These relationships with symbionts are metabolically costly," she said. "Plants have to pay the microbes in photosynthesised sugar, and in exchange the microbes mine the soil for nutrients. Microbial symbionts can be really expensive subcontractors, sometimes taking a significant fraction of a plant's photosynthate.

"What Ilenne and Tara have shown is one mechanism through which plants can control whether they invest in expensive symbionts," she said. "Among a wide class of signalling compounds used by plants for many purposes, one specific signal related to nutrients is shut off by high soil organic matter, which is a slow-release source of nutrients. The plant signal that says 'come live with us' doesn't get through.

"This is good for plants because it means they don't waste photosynthate supporting microbial help they don't need. Ilenne and Tara have also shown that signals used for other purposes are slightly chemically modified so their transmission is not affected at the same rate."

The researchers checked flavonoid concentrations in soil with standard chromatography as well as unique fluorescent and gas biosensors, genetically modified microbes introduced in 2016 with the support of a Keck Foundation grant, which also backed the current project. The microbes release a gas when they sense a particular microbial interaction in opaque materials like soil.

"The gas sensor ended up being very useful in experiments that looked like tea, where we couldn't image fluorescent signals," Silberg said.

Journal Reference:

Ilenne Del Valle, Tara M. Webster, Hsiao-Ying Cheng, Janice E. Thies, André Kessler, Mary Kaitlyn Miller, Zachary T. Ball, Kevin R. Mackenzie, Caroline A. Masiello, Jonathan J. Silberg, and Johannes Lehmann. Soil organic matter attenuates the efficacy of flavonoid-based plant-microbe communication. Soil Advances, 2020 DOI: 10.1126/sciadv.aax8254

EXPAND YOUR KNOWLEDGE WITH THE AUSTRALIAN AGRONOMIST MAGAZINE.

The Australian Agronomist is the only agronomy publication of its kind, ensuring agronomists and consultants across all industry sectors stay up to date with the latest information and news.

YOU COULD WIN A GIFT PACK OF ELLIS WINES FROM HEATHCOTE SUBSCRIBE TODAY!

Subscription options:

MAIL
PO Box 812 Strathfieldsaye,
VIC Australia 3551

EMAIL
info@theaustralianagronomist.com

ONLINE
www.theaustralianagronomist.com

Subscribe today for only

$40 for 4 issues (1 year subscription) | **$65 for 8 issues** (2 year subscription)

Personal details

Name
Address

Postcode
Telephone
Email

Payment:

- PAYPAL Subscribe online via our website
- CHEQUE To be made out to Regional Reach Pty Ltd
- CREDIT CARD Please fill in the details below:
  - VISA
  - MASTERCARD

Expiry Date: __ __ / __ __

Card Number:

Security Code (CVC): last three digits on signature strip

Number of issues:

- **$40** - 4 issues
- **$65** - 8 issues

TERMS AND CONDITIONS: Your subscription will start with the next available issue. You will receive either 4 or 8 issues. Minimum term of 12 months.

WWW.THEAUSTRALIANAGRONOMIST.COM

SOLVING THE RIDDLE OF STRIGOLACTONE BIOSYNTHESIS IN PLANTS

Strigolactones (SLs) are a class of chemical compounds found in plants that have received attention due to their roles as plant hormones and rhizosphere signalling molecules. They play an important role in regulating plant architecture, as well as promoting germination of root parasitic weeds[1] that have great detrimental effects on plant growth and production.

This study was conducted as part of the SATREPS[2] (Science and Technology Research Partnership for Sustainable Development) program by Dr. Wakabayashi, Prof. Sugimoto and their colleagues at the Graduate School of Agricultural Science, Kobe University, in collaboration with researchers from the University of Tokyo and Tokushima University. They discovered the orobanchol synthase responsible for converting the SL carlactonoic acid, which promotes symbiotic relationships with fungi, into the SL orobanchol, which causes root parasitic weeds to germinate.

By knocking out[3] the orobanchol synthase gene using genome editing, they succeeded in artificially regulating SL production. This discovery will lead to greater understanding of the functions of each SL and enable the practical application of SLs in the improvement of plant production.

The results of this study were published in the International Scientific Journal Science Advances in December 2019.

Main points

- Strigolactones are known to have various functions such as the development of plant architecture, promoting mutually beneficial mycorrhizal relationships with fungi and serving as germination signals for root parasitic weeds.
- Strigolactones are classified into canonical and non-canonical SLs based on their chemical structures. Canonical SLs have an ABC ring, whereas non-canonical SLs have an unclosed BC ring.
- This study discovered the synthase gene responsible for converting the non-canonical SL carlactonoic acid into the canonical SL orobanchol.
- The group succeeded in generating tomato plants with the synthase gene knocked out in which carlactonoic acid (CLA) accumulated and orobanchol production was prevented. The germination rate of root parasitic weeds was lower for these knock out plants.

Research Background

Strigolactones (SL) are a class of chemical compounds that were initially characterised as germination stimulants for root parasitic weeds. SLs have also received attention for their other functions. They play an important role in controlling tiller bud outgrowth and also in promoting mycorrhizal symbiosis in many land plants, whereby plants and fungi mutually exchange nutrients.

Up until now, around 20 SLs have been isolated; with differences in stereochemistry in the C ring and modifications in the A and/or B rings. In recent years, SLs with unclosed BC rings have been discovered. Currently, SLs with a closed ABC ring are designated as canonical SLs, whereas SLs with an unclosed BC ring are non-canonical SLs. However, it is not clear which compounds function as hormones and which compounds function as rhizosphere signals.

If SL production could be suppressed, plants would induce the germination of fewer root parasitic weeds and their adverse effects on crop production would be mitigated. By increasing SL production, on the other hand, plant nutrition would be improved through the promotion of relationships with mycorrhizal fungi. Furthermore, manipulation of the endogenous levels of SL would control plant architecture above ground. Understanding the functions of individual SLs would lead to the development of technology to artificially control plant architecture and the rhizosphere environment. Consequently, there is much interest in how these SLs are biosynthesised.

It has been elucidated that SLs are biosynthesised from?-carotene. Four enzymes are involved in conversion of?-caroteneto carlactonoic acid (CLA), a common intermediate of SL biosynthesis. In Japonica rice, conversion of CLA into orobanchol proceeds with two enzymes catalyzing two distinct steps. However, the biosynthesis pathway for orobanchol in other plants remained unknown. This study discovered the novel orobanchol synthase, which converts CLA into orobanchol in cowpea and tomato plants.

Research Methodology

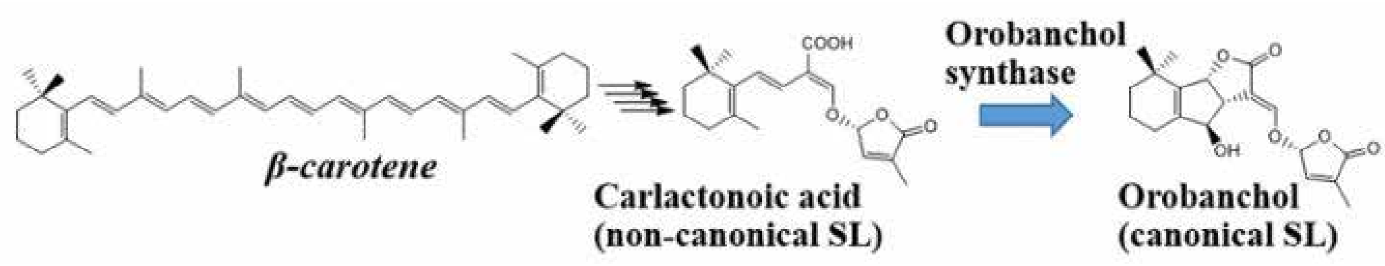
This research group had isolated orobanchol from cowpea root exudates and determined the structure. From metabolic experiments using cowpea, it was predicted that cytochrome P450[4] would be involved in the conversion of CLA into orobanchol. In this study, cowpea plants were grown in phosphate rich and poor conditions, where orobanchol production was restricted and promoted, respectively. The genes expressed in the roots of plants in both conditions were comprehensively compared. The group screened for CYP genes whose expression correlated with orobanchol production, expressed them as recombinant proteins, and performed an enzyme reaction assay.

From these results, it was understood that the VuCYP722C enzyme catalysed the conversion of CLA to orobanchol. Furthermore, the SlCYP722C gene, a homolog[5] of VuCYP722C in tomato was confirmed to be an orobanchol synthase gene. The SlCYP722C gene was knocked out (KO) in tomato plants using genome editing. In contrast to the wild type (control) tomato plants, orobanchol was not detected in root exudates of the KO plants, with CLA being detected instead.

Thus, the research group proved that SlCYP722C is the orobanchol synthase in tomato that converts the non-canonical SL CLA into the canonical SL orobanchol. The architecture of the KO and wild-type plants was comparable (Photo 1). This demonstrated that orobanchol doesn't control plant architecture in tomato plants. It is thought that these KO tomato plants would still be able to benefit from mycorrhizal fungi, as the activity of CLA against the hyphal branching of the fungi was comparable with that of canonical SLs. Furthermore, it was found that the germination rate of the root parasitic weed Phelipanche aegyptiaca was significantly lower in the hydroponic media of the KO tomato plants. P. aegyptiaca causes great damage to tomato production all over the world, especially around the Mediterranean region. This research showed that it is possible to limit the damage that this parasitic weed does to tomato production by knocking out the orobanchol synthase gene.

Further Research

This research group succeeded in preventing the synthesis of the major canonical SL orobanchol and accumulating the non-canonical SL carlactonoic acid. The same method can be utilised to elucidate the genes responsible for the biosynthesis of other canonical SLs. Further understanding of the functions of various SLs would allow plants to be manipulated in order to maximize their performance under adverse cultural conditions. Root parasitic weeds detrimentally affect not only tomato but a wide range of other crops including species of Solanaceae, Leguminoceae, Cucurbitaceae and Poaceae. These results will lead to the development of research to alleviate the damage inflicted by root parasitic weeds and increase food production worldwide.



University of Delaware Professor Jung-Youn Lee (right) and postdoctoral researcher Gabriel Robles Luna discuss lateral root structures. Lee's research team continues to study the role of plasmodesmal proteins in plant communication. Photo credit: Monica Moriak/ University of Delaware

Glossary

1. Root parasitic weeds These are weeds that connect with other plants underground and feed off them. Root parasitic weeds can cause great damage to food crops. For example, Orobanche spp. parasitise a wide range of crops including species of Solanaceae, Leguminoceae, Curcurbitaceae and Umbelliferae. The root parasitic weed Striga spp. have a particularly detrimental effect on grain crops, reducing their yield. The establishment of effective countermeasures is an urgent research topic because the damage inflicted by root parasitic weeds to crops is serious across the globe.

2. SATREPS SATREPS is a Japanese government program that promotes international joint research, co-sponsored by JST (Japan Science and Technology agency) and JICA (Japan International Cooperation Agency). It aims to find solutions for global issues by promoting 3-5 year research collaborations between researchers from Japan and developing countries. JST provides funding for research within Japan and outside the partnership country. If funding is necessary for the partnership country, JICA provides ODA within the framework of technical cooperation projects. The two organisations work together utilising their respective strengths; JST's expertise in funding domestic research projects and JICA's expertise in technical cooperation in developing countries.

3. Genome editing and gene knock out Genome editing is a type of genetic engineering which involves making specific modifications to the DNA of a living organism. The DNA is cut at a specific sequence by an engineered nuclease. This cut is repaired through non-homologous end-joining by the cell, resulting in a change to the targeted sequence. This allows small additions or deletions to be made to the DNA and for the function of a specific gene to be removed (knock out).

4. Cytochrome P450 Part of the hemoprotein family. It is called "P450" because the maximum wavelength of the enzymes' absorption is 450 nm when in its reduced state and complexed with carbon monoxide. The existence of cytochrome P450 has been confirmed in a variety of organisms. These hemoproteins are involved in the synthesis of hormones and secondary metabolites, and drug metabolism.

5. Homolog A gene that resembles another gene due to shared ancestry.

This research was supported by the JST/JICA SATREPS program (JPMJSA1607) 'Improvement of Food Security in Semi-arid Regions of Sudan through Management of Root Parasitic Weeds (Striga)'(Principal Investigator: Professor SUGIMOTO Yukihiro), and the JSPS KAKENHI (19H02897) for the 'Elucidation of strigolactone BC ring formation mechanism aiming at elucidation of the active ingredient as branching inhibitory hormone' (PI: Professor SUGIMOTO Yukihiro) among others.

Journal Reference:

Takatoshi Wakabayashi, Misaki Hamana, Ayami Mori, Ryota Akiyama, Kotomi Ueno, Keishi Osakabe, Yuriko Osakabe, Hideyuki Suzuki, Hirosato Takikawa, Masaharu Mizutani, Yukihiro Sugimoto. Direct conversion of carlactonoic acid to orobanchol by cytochrome P450 CYP722C in strigolactone biosynthesis. Science Advances, 2019; 5 (12): eaax9067 DOI: 10.1126/sciadv.aax9067

'RULE BREAKING' PLANTS MAY BE CLIMATE CHANGE SURVIVORS

Plants that break some of the 'rules' of ecology by adapting in unconventional ways may have a higher chance of surviving climate change, according to researchers from the University of Queensland and Trinity College Dublin.

Dr Annabel Smith, from UQ's School of Agriculture and Food Sciences, and Professor Yvonne Buckley, from UQ's School of Biological Sciences and Trinity College Dublin Ireland, studied the humble plantain (Plantago lanceolate) to see how it became one of the world's most successfully distributed plant species.

"The plantain, a small plant native to Europe, has spread wildly across the globe - we needed to know why it's been so incredibly successful, even in hot, dry climates," Dr Smith said.

The global team of 48 ecologists set up 53 monitoring sites in 21 countries, tagged thousands of individual plants, tracked plant deaths and new seedlings, counted flowers and seeds and looked at DNA to see how many individual plants have historically been introduced outside Europe.

What they discovered went against existing tenets of ecological science.

"We were a bit shocked to find that some of the 'rules of ecology' simply didn't apply to this species," Dr Smith said.

"Ecologists use different theories to understand how nature works - developed and tested over decades with field research - these are the so-called 'rules'.

"One of these theories describes how genetic diversity or variation in genes embedded in DNA are produced by changes in population size.

"Small populations tend to have little genetic diversity, while large populations with many offspring, such as those with lots of seeds, have more genetic diversity.

"Genetic diversity sounds boring, but actually it's the raw material on which evolution acts; more genetic diversity means plants are better able to adapt to environmental changes, like climate change.

"We discovered that, in their native range, the environment determined their levels of genetic diversity.

"But, in new environments, these rule breakers were adapting better than most other plants."

The team found the plantain's success was due to multiple introductions around the world.

Professor Buckley, who coordinates the global project from Trinity College Dublin Ireland, said the DNA analysis revealed that ongoing introductions into Australia, NZ, North America, Japan and South Africa quickly prompted genetic diversity,

It gave these 'expats' a higher capacity for adaptation," Professor Buckley said.

"In Europe plantains played by the rules, but by breaking it outside of Europe, it didn't matter what kind of environment they were living in, the plantains almost always had high genetic diversity and high adaptability."

Dr Smith said the finding was fascinating and critical, for two crucial reasons.

"It's important we now know that multiple introductions will mix genetic stock and make invasive plants more successful quite quickly - an important finding given invasive species cause extinction and cost governments billions of dollars," she said.

"And secondly, research on invasive plants gives us clues about how our native plants might adapt to climate change.

Journal Reference:

Annabel L. Smith, Trevor R. Hodkinson, Jesus Villellas, Jane A. Catford, Anna Mária Cserg- , Simone P. Blomberg, Elizabeth E. Crone, Johan Ehrlén, Maria B. Garcia, Anna-Liisa Laine, Deborah A. Roach, Roberto Salguero-Gómez, Glenda M. Wardle, Dylan Z. Childs, Bret D. Elderd, Alain Finn, Sergi Munné-Bosch, Maude E. A. Baudraz, Judit Bódis, Francis Q. Brearley, Anna Bucharova, Christina M. Caruso, Richard P. Duncan, John M. Dwyer, Ben Gooden, Ronny Groenteman, Liv Norunn Hamre, Aveliina Helm, Ruth Kelly, Lauri Laanisto, Michele Lonati, Joslin L. Moore, Melanie Morales, Siri Lie Olsen, Meelis Pärtel, William K. Petry, Satu Ramula, Pil U. Rasmussen, Simone Ravetto Enri, Anna Roeder, Christiane Roscher, Marjo Saastamoinen, Ayco J. M. Tack, Joachim Paul Töpper, Gregory E. Vose, Elizabeth M. Wandrag, Astrid Wingler, Yvonne M. Buckley. Global gene flow releases invasive plants from environmental constraints on genetic diversity. Proceedings of the National Academy of Sciences, 2020; 201915848 DOI: 10.1073/pnas.1915848117

NITROGEN FIXATION IN AGRICULTURE BY MUTUALISTIC AND FREE LIVING BACTERIA

BY DR. UWE STROEHER, MICROBIOLOGIST

NITROGEN, TOGETHER WITH POTASSIUM AND PHOSPHATE, ARE THE MOST WIDELY USED FERTILISERS IN THE WORLD. UNTIL THE ADVENT OF THE HABER-BOSCH PROCESS IN THE EARLY 1900S WHICH ALLOWS THE CHEMICAL SYNTHESIS OF NITROGEN FERTILISERS, THE WORLD WAS RELIANT ON ORGANIC FERTILISERS AND THE ABILITY OF BACTERIA TO FIX ATMOSPHERIC NITROGEN (ERISMAN ET AL., 2008).

Fig. 1 Nitrogen fixing nodules on legume roots

There is no doubt that without the use of chemical nitrogen we would not be able to feed the world's population, however nitrogen from chemical fertilisers comes at enormous cost, both financially and environmentally. Production of nitrogen fertilisers alone requires over 1% of the worlds' energy, and it's this high energy requirement that is at the crux of turning atmospheric nitrogen into a plant-useable form such as ammonia.

In the atmosphere, nitrogen is a molecule of two tightly bound nitrogen atoms which need to be split to combine with hydrogen to form ammonia or oxygen - which then forms nitrites or nitrates. This occurs in nature during lightning, where the molecules are torn apart and can then combine with oxygen. Alternatively, it can occur via a biological process driven by a number of bacterial species. In the soil, nitrogen fixation occurs either within plant tissues of legumes, or within the soil itself by free living bacteria.

Most people are aware of the nodules that form on the roots of legumes - it is within these structures that bacteria fix nitrogen *(Fig. 1)*. For each legume species there exists a distinct set of Rhizobium species which associates with the roots and forms these nodules. For example, bacteria found in peas will not associate with beans or lentils. This interaction is extremely specific, and is driven by the bacteria and the plant, and only occurs when the plant is under limited nitrogen conditions (Maróti and Kondorosi 2014).

Initially, the plant roots release compounds known as flavonoids, which attract soil bacteria such as Rhizobia that are capable of fixing nitrogen, and the bacteria start to multiply near the root *(Fig. 2)*. This process is not 100% specific, but can also recruit other bacteria which may be undesirable. Therefore, the plant 'looks' for a bacterial signal, which communicates to the plant that the bacteria is capable of nodule formation and nitrogen fixation. This signal is called the nodulation factor, and causes the root hair to curl, forming an infection thread.

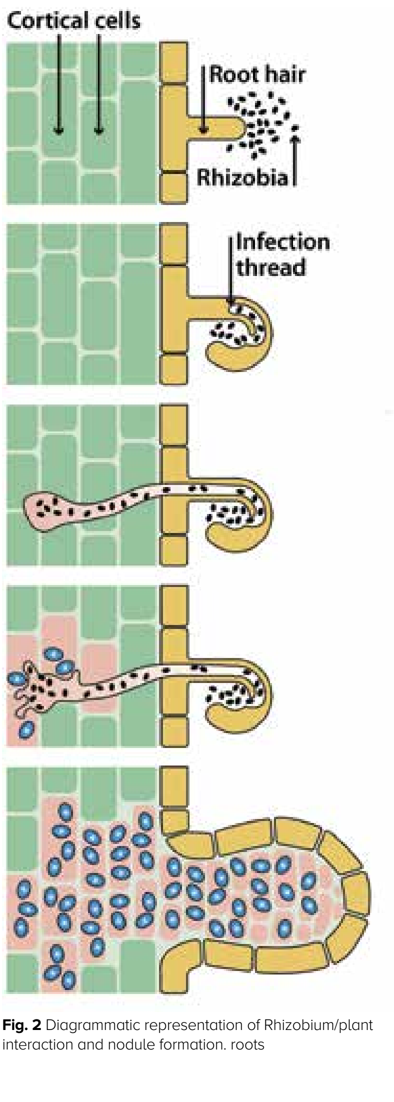


Fig. 2 Diagrammatic representation of Rhizobium/plant interaction and nodule formation. roots

A mutualistic relationship is then established between the plant and bacteria, and the bacteria enters the root cortex via the infection thread. Once the bacteria are released from the infection thread, they become bacteroids and multiply (refer to the blue shapes in *Fig. 2*). Similarly, the plant root cells surrounding the bacteroids start to divide and begin nodule formation.

Although nodules may be present, the process of nitrogen fixation requires some additional factors to be met. Firstly, the plant must be in a low nitrogen environment. If levels of nitrogen are high, nodulation may not occur, or the nodules will not fix nitrogen. Secondly, nitrogen fixation only occurs if it is within the plant nodules or in the soil where there is an environment of low oxygen. To achieve this within the nodules, the plant produces a protein known as leghaemoglobin (also known as legoglobin), which has a very high affinity for oxygen, and provides a low-oxygen environment for nitrogen fixation. The requirement for low oxygen is due to the sensitivity of the nitrogenase enzymes, which are essential for nitrogen fixation and provided by the bacteria.

Similar to human haemoglobin, Leghaemoglobin is red in colour, and only nodules that show a pinkish or red/brown internal colouration are capable of fixing nitrogen. Nitrogen fixation is tightly controlled and regulated because it is extremely energy intensive, and only occurs when required. Therefore, whereas the plant obtains a ready source of nitrogen, the bacteria is given carbohydrates to produce the energy for nitrogen fixation and for general bacterial metabolism, and the nodule provides a niche that is free of competing microbes, giving the Rhizobium a distinct advantage.

Legumes are generally grown as either a high-protein livestock food or a crop, and can fix in excess of 200kg of nitrogen per hectare, however not all of this nitrogen is available for subsequent crops, as the plant depletes the ammonia levels within the nodule during flower and seed production.

If the legumes are grown for their ability to fix nitrogen as a cover crop and to enrich the soil for a subsequent harvest, then this crop should be ploughed back into the ground just after the first sign of flower setting. After this point, nitrogen in the nodules is starting to be drawn out for flowering and seeds. For some legumes, 40% of the fixed nitrogen is eventually trapped in the seed. Once ploughed back into the soil, the plant, roots and nodules break down, thereby releasing nitrogen for other crops.

Surprisingly, nitrogen fixation is not limited to the mutualistic relationship discussed above, but is also undertaken by a number of free living soil bacteria. Amongst the most important are species of Azotobacter and Clostridium - their ability to fix nitrogen is lower (around 30kg per hectare), yet they still represent significant nitrogen fixation. The requirements to fix nitrogen by these bacteria is no different to the Rhizobium. Within the soil - and in particular the rhizosphere - there are plant-secreted carbohydrates which are used in part to energise nitrogen fixation. The issue of low oxygen concentration is overcome in Azotobacter by the production of a slime layer which lowers the intracellular oxygen concentration. As Clostridium grow in anaerobic environments, oxygen is not an issue. In essence, nitrogen fixation occurs in almost all microbiologically-active soils and is not restricted to legumes.

The last group of nitrogen-fixing bacteria are the cyanobacteria - these play a significant role in nitrogen fixation in wet soils or in environments such as rice paddies. In this instance, they fix approximately 20-30 kg of nitrogen per hectare. Cyanobacteria are photosynthetic so they are not dependent on an external source of carbohydrates for their energy. Furthermore, they have specialised structures called heterocycsts where low levels of oxygen are produced and nitrogen fixation occurs.

Thus, in order to maximise nitrogen fixation, there are a number of factors to consider. For legumes, various Rhizobium inoculants are available to increase nodule formation, however this will do little unless other factors are met. The most obvious is to ensure nitrogen fertilisers are used at a level which requires legumes to fix atmospheric nitrogen. This is also the case for free living nitrogen-fixing bacteria. Secondly, this is a biological reaction, so an environment that encourages microbial diversity is best. Furthermore, if legumes are stressed due to environmental factors or an imbalance of nutrients, then nitrogen fixation suffers. Ensuring a ready supply of phosphorus, potassium, sulphur, zinc, iron, cobalt and molybdenum will enhance nitrogen fixation. An organic fertiliser such as Neutrog's Rapid Raiser will provide these nutrient requirements without adding excessive nitrogen.

CROPS HIT BY UNFAVOURABLE CONDITIONS

In its Australian crop report – February 2020, ABARES says production prospects for summer crops in Queensland and northern New South Wales remain well below average.

Peter Gooday, acting Executive Director of ABARES, said that this is an extremely trying time for many crop growers, especially those in New South Wales and Queensland.

“Summer crop prospects were adversely affected by unfavourable seasonal conditions in December that further depleted soil moisture levels to well below average in most summer cropping regions and to record lows in some others”, Mr Gooday said. “With the planting of summer crops in Queensland and northern New South Wales now largely complete, we expect planted area and production to be lower than our forecasts of December 2019.

“This largely reflects seasonal conditions in December that were more unfavourable than expected.

“Rainfall in late January and in February was largely too late to plant more grain sorghum in southern Queensland and northern New South Wales.

“The Bureau of Meteorology’s latest three-month rainfall outlook indicates that for most summer cropping regions in Queensland and northern New South Wales rainfall is more likely to be below average than above average from March to May.

“We are likely to see a 66% decrease in summer crop production down to 878,000 tonnes.

“Cotton production is forecast to fall by 72% to around 135,000 tonnes of lint and 191,000 tonnes of seed.

“Grain sorghum production is expected to be down by 77% to around 292,000 tonnes.

“Rice production will remain low at around 54,000 tonnes due to low water allocations and high water prices.

“ABARES’ winter crop production estimate for 2019-20 will remain largely unchanged from our forecast of December 2019 at around 29 million tonnes.

“Higher than expected barley and canola production is estimated to have largely offset lower than expected wheat production.”

IMPACT OF DROUGHT BECOMING MORE PRONOUNCED

The effects of the continuing drought are becoming more pronounced with falling production and high input costs presenting serious challenges in many regions, especially in New South Wales and Queensland according to the latest Agricultural Commodities report launched today.

ABARES’ Chief Commodity Analyst Peter Gooday, said the total volume of agricultural production is forecast to fall for a third-consecutive year, which hasn’t happened for more than 60 years.

“The value of agricultural production is forecast to fall by 3 per cent this year, but still remain high at almost $61 billion, supported by strong demand for livestock products resulting from the African swine fever outbreaks across Asia,” Mr Gooday said.

“We’re expecting to see higher prices year-on-year for cattle, sheep, lambs, pigs and goats which will partly offset the decline in production.

“Winter crop production has been revised down after a challenging spring in many regions and the poor conditions will see continued turnoff of livestock - but production is expected to fall as fewer animals are available for slaughter.

“Fodder availability is likely to be higher in 2019-20 than last season and prices are expected to fall, but they are likely to remain well above average - a poor summer crop could add pressure to prices later in the year.

“The value of agricultural exports is forecast to fall by 8 per cent to $45 billion - the main drivers of this are lower crop and livestock production and a diversion of grain to the domestic market for feed and human consumption.

“While cropping can be expected to rebound quickly once seasonal conditions improve, the livestock sector will require a longer period for pasture to recover and begin herd rebuilding- the national cattle herd is forecast to fall to the lowest level since the early 1990s.”

Read the full report at: agriculture.gov.au/abares/research-topics/agricultural-commodities/dec-2019

BIOLOGICAL DIVERSITY AS A FACTOR OF PRODUCTION

The main question addressed by the study is: Does greater biodiversity increase the economic value of managed ecosystems? "We have found that the possible relationships between economic value and biodiversity are varied," says Professor Thomas Knoke, Head of the Institute of Forest Management at the TUM School of Life Sciences Weihenstephan.

It all depends on the purpose

Even a layman can guess the main purpose of single-species timber plantations: economic benefit through the sale of wood. But forests have a number of functions. They serve as home to a variety of animal and plant species, function as a source of wood as a raw material, have a protective function such as protecting the soil and helping combat global warming and serve recreational purposes as well.

It is common ecological knowledge that the more biodiverse a forest is, the higher the productivity will be. However, the researchers found that "after you have reached a certain mix of trees, adding new species no longer produces significant economic benefits to people." What counts here are the characteristics of the species of trees inhabiting the forest as not every tree has the same value.

"The different functions of an ecosystem never stand to an equal degree in positive relation to biodiversity," explains Carola Paul, University of Göttingen, who until recently was a member of Thomas Knoke's team. If you were to compile all functions of an ecosystem, you would find a mathematical maximum in terms of its value.

The team found that, "maximising biodiversity at the level of the ecosystem does not maximise economic value in most cases." This particularly holds true if compromises have to be made between different purposes or different economic yields and risks. In such cases, applying a medium level of biological diversity proves most beneficial.

Where biodiversity pays off

The more diverse the plants in an ecosystem are, the better the situation is in terms of risk diversification. This affects the variability of cash value of the ecosystem. The research shows that risk premiums can be lowered just by making a minor change to the level of biodiversity. Risk premium is the reward that a risk-averse person requires to accept a higher risk.

The researchers identified high value potential in biodiversity particularly in connection with the avoidance of social costs. These costs are borne by the public such as diseases caused by air pollution. In its mathematical calculations of these social costs, the study argues that more diverse, mixed agriculture and forest management systems pay off. "Biodiverse ecosystems require less pesticides and fertiliser," explains Thomas Knoke.

A medium degree of biodiversity often creates the best value

"Based on theoretical considerations and empirical evidence, we have found that ecosystems with several, but in all actuality relatively few, plant species can produce more economic benefits than those with only one species as well as those with a large number of species," the scientist summarises.

According to the research, biodiversity and ecosystem functionality rarely create a consistent upward curve. Instead, the team found empirical and theoretical evidence of strictly concave or strictly convex relationships between biodiversity and economic value.

These findings in no way indicate that mega biodiverse ecosystems are not worth protecting. Instead they show that economic arguments alone are not sufficient when talking about these biodiversity "hot spots."

What the relationships do highlight are the economic benefits that even a minor increase in biodiversity could have in the agricultural sector. When it comes to forests, the study shows that it is possible to manage a stable forest that serves a variety of functions with four to five species of trees. The relationships identified in the study can therefore be of considerable value in land use planning going forward.

Journal Reference:

Carola Paul, Nick Hanley, Sebastian T. Meyer, Christine Fürst, Wolfgang W. Weisser, Thomas Knoke. On the functional relationship between biodiversity and economic value. Science Advances, 2020; 6 (5): eaax7712 DOI: 10.1126/sciadv.aax7712

SMOOTH START FOR NEW LIQUID FORM OF POPULAR HERBICIDE

Farm Manager Austin Rayner took the opportunity to trial a new liquid version of the popular pre-emergent herbicide, Sakura, on the EF Smart Pty Ltd property near Nabawa in Western Australia's northern wheatbelt and it proved to be a seamless transition.

Sakura, as the water dispersible granule (WG) formulation, played a vital role on the property to help limit annual ryegrass populations and also suppress brome grass.

Austin manages a 15,100-hectare cropping program comprising wheat, canola and lupins on country ranging from strong red loams through to yellow sandplain soils at the 'Wicka' farm in the Chapman Valley Shire.

Sakura has traditionally been applied in paddocks that in the previous season have been worked to a depth of 30-35 centimetres with a 13-furrow mouldboard plough to help improve non-wetting soils, as well as in any "dirty" (weedy) paddocks.

"We have generally mouldboarded and gone straight in with wheat and no chemical, and then in the second year have continued with wheat and Sakura," Austin said. "It is generally applied every second year. It seems to be one of the safest 'pre-ems' (pre-emergent herbicides) and has helped to keep the ryegrass numbers low.

"We have used Treflan and normal knockdown (herbicides) with Sakura and we also use Boxer Gold® in the rotation, but we find other pre-emergents can hot-up crops in the early years after mouldboarding."

He said Sakura had definitely helped to "clean-up" paddocks and had performed well even in high trash years.

The Group K herbicide is incorporated during sowing with Ausplow DBS rigs set on 30-centimetre tyne spacings.

The new Sakura Flow suspension concentrate (SC) formulation now available is applied at the low rate of 210 mL/ha. It provides up to 12 weeks residual control of annual ryegrass, barley grass, annual phalaris, silver grass and toad rush in wheat (except durum wheat), triticale, chickpeas, field peas, lentils and lupins, as well as for suppression of brome grass and wild oats.

The convenient liquid option, offering the same compatibility as the granule formulation with a wide range of herbicides, is also easy to measure and mix, eliminating any need for scales and helping to save time filling spray tanks.

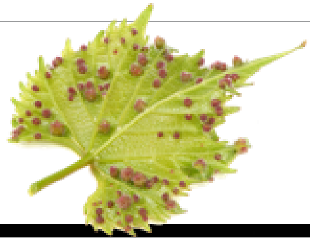
Austin said he applied 20 litres of Sakura Flow with some Roundup knockdown herbicide over 95 ha in a paddock sown to wheat that had a higher annual ryegrass population and which also included rocks and areas that were spaded and not sprayed. It was applied with 100 L/ha of water as a coarse droplet using a John Deere 4060 self-propelled sprayer.

"It did save having to weigh granules (with the WG formulation) before adding them to the tank, plus everything went through the boom well and the ryegrass control was good," Austin said.

For next season, Bayer is evaluating grower interest in larger format packs of Sakura Flow, which would allow direct transfer into spray tanks. Extensive trials throughout Australia's grain growing regions with both liquid and granule formulations of Sakura in wheat have also shown comparable performance for annual ryegrass control.

In the last two years in the northern wheatbelt, good opening rains have provided perfect conditions for excellent grass control with Sakura and Austin said while it had predominantly been applied in dry conditions this season, it had proven effective in continuing to maintain a mainly low weed seed bank.

NEW PORTABLE GENETIC TEST FOR PHYLLOXERA



Agriculture Victoria scientists have developed a world-leading test for rapid, in-field detection of the number one biosecurity threat to Australia's grapevines - grape phylloxera.

Grape phylloxera is a tiny aphid-like insect pest that destroys vines by feeding on their roots and can wipe out entire vineyards within six years.

It is considered the most serious insect pest threatening the profitability of Victoria's $900 million table grape and wine industries.

Managing a grape phylloxera-infected vineyard can increase on-farm costs by up to 20 per cent and outbreaks can reduce vineyard profitability by up to 50 per cent over 20 years.

Rapid and accurate detection is critical to containing the spread of phylloxera and minimising industry impacts.

The new portable genetic test developed by Agriculture Victoria can be used to detect grape phylloxera in the field in less than an hour, compared to several days in a laboratory.

Agriculture Victoria scientist Dr Mark Blacket said the test will enable easier and more effective surveillance of this serious pest.

"This new test will help to stop the spread of grape phylloxera between properties by enabling growers and biosecurity officers to detect it much sooner," Dr Blacket said.

"The fact that biosecurity officers can now conduct rapid testing in the field means growers can better manage positive cases," he said.

Grape phylloxera is found in Victoria and New South Wales and there is no way to rid the vines of the pest once they are affected, making early detection and quarantine measures critical to its control.

The new genetic test uses portable LAMP (loop-mediated isothermal amplification) technology to analyse insect DNA.

The test is currently being used by Agriculture Victoria through its Crop Health Services at the AgriBio Centre for AgriBioscience in Victoria and is available for Agriculture Victoria's biosecurity officers to use in the field.

Together with Agriculture Victoria's Tackling Phylloxera Program - a state-wide project that aims to address the biosecurity challenges posed by phylloxera - it will improve the productivity of Victoria's grape industries and allow for more efficient supply chains.

SPRING TYPE CLEARFIELD CANOLA YIELDS SURPRISING RESULTS PLANTED EARLY

In early Autumn 2019, a mixed farmer in Serpentine, Central Victoria was looking at options to fill the feed gap for his sheep enterprise. In doing so, the business opted to sow a true winter type canola. They also planted Pioneer 45Y93 (CL), which is a spring canola type. The grower sowed both varieties of canola on April 4 and irrigated accordingly.

Prior to grazing the 45Y93 (CL) displayed good biomass, which provided an excellent feed wedge of early winter feed. Early biomass seen in NDVI images demonstrated the increased biomass of 45Y93 (CL) compared with the winter type.

612 first cross ewes and 720 lambs grazed the 13ha paddock for 20 days between June 7 & June 27.

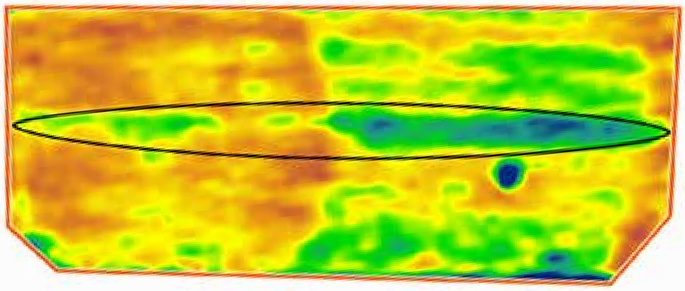
David Smyth, Pioneer Farm Services Consultant for Central Victoria said, "When grazing you need to be mindful of grazing pressure and the time period available for the plant to regenerate a canopy prior to the reproductive phase."

He kept a close eye on the crop throughout the season, providing the grower information on grazing timing and post graze urea applications. "It is important to note that; locking up paddocks no later than the end of June and additional nutrition will be required post grazing to achieve target yields."

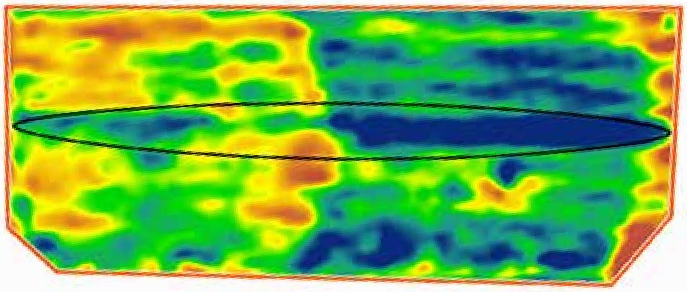
Post grazing, the 45Y93 (CL) recovered very well, and the grazing has resulted in the plant branching, increasing its pod density and potential yield.

The 45Y93 (CL) was at full flower in early September, while the winter type was still in the vegetative state. Post grazing the 45Y93 (CL) was irrigated once prior to harvest, while the winter type received 2 irrigations. The 45Y93 (CL) was windrowed on the 16th November, while the winter type was windrowed 10 days later.

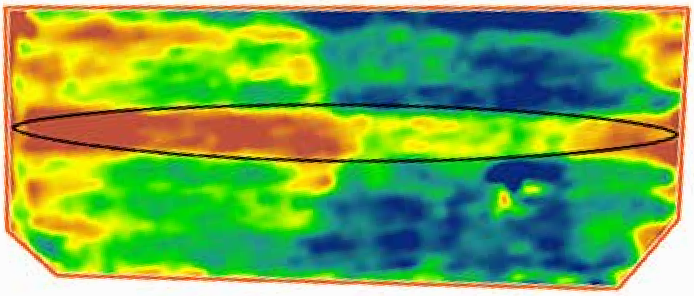
Both the 45Y93 (CL) and the winter type were harvested on the 13th December. The 45Y93 (CL) yielded 2.96t/ha, while the winter type yielded 1.70t/ha in the trial paddock.



May 6 - Biomass easily recognisable in pre graze NDVI image



May 16 - Biomass easily recognisable in pre graze NDVI image



NDVI image post grazing identifies the strip where the 45Y93 CL is. There is less biomass as the sheep have grazed the 45Y93 CL more heavily than the winter type.

Strong regrowth on the 45Y93 CL following heavy grazing.

The paddock post grazing.

PROFESSIONAL ACCREDITATION - MORE THAN A POINT OF DIFFERENCE

Anyone working within, or on the fringes of the Australian Agriculture over the past twelve or so months would be forgiven for feeling just a little battle weary. The combined impacts of drought, bushfires, and battles over water have brought the industry and its players under increased public scrutiny and in many cases criticism.

Water is the obvious catalyst and regardless if it is knowledgeable debate or ill-informed criticism, the agricultural sector is under increased pressure to validate its social licence to farm. The onus remains quite squarely with us as industry professionals to proactively work towards rebuilding the battered public image of the agricultural sector and validate our social license to farm.

This will be a slow process, but it begins with each of us continuing to display professionalism and best practice in our everyday work. Few of the critics would be aware of the level of study, professional development and on ground research that backs up the daily decision making and long term planning within this industry.

The findings of the recent Australian Royal Banking Commission highlighted the importance of qualifications and experience when making recommendations. Practicing financial advisors are now bound by a new set of prerequisites and regulations in an effort to improve the professionalism of the industry and ultimately, outcomes for the Australian consumer. This has been a top down approach imposed on the industry after its failings were displayed and customers had suffered. This is an outcome from which the agricultural sector has a lot to learn.

For many reasons over the years, the suggestion of compulsory accreditation of Agricultural professionals, has caused division and anxiety. There have been concerns regarding overregulation, red tape, extra cost burdens to small business operators and lack of recognition of prior learning and hard-earned experience. While it is easy to list the drawbacks, such an accreditation could form part of the key to revalidating our credibility.

For many years, CCA has offered its own recognition of members who provide annual evidence of their annual upskilling. These members have been promoted by the organisation as professional, are entitled to use their accreditation as part of the marketing and branding. This acknowledgement is available solely to members of CCA and is mirrored in many associated professional groups including the Soil Society of Australia's Certified Practising Soil Scientist (CPSS) and AgSafe®. 2

In November 2018, a long awaited and overarching "whole of industry" accreditation was launched by the Ag Institute of Australia (AIA). Rather than duplicating existing programs, candidates are offered the opportunity to build on their existing accreditation, through the Chartered Practicing Agriculturist (CPAg) scheme. The scheme enables participants to track their ongoing professional development experiences and activities including research, ongoing study and extension activities. AIA has allocated a CPD value to many of these activities however organisations are welcome to submit events and activities for assessment of their continuing professional development point (CPD) value. Practicitioners who achieve CPAg statues are able to use the post nominals CPAg after their name and the logo in marketing materials.

Taking the program to a completely different level, the AIA's Chartered Agriculturalist scheme (CAg) provides an opportunity for recognition of professionals at a more advanced stage of their career. Successful candidates are recognised for their leadership, commitment to professionalism, accountability and ethical practices and their demonstrated their skills and competencies. Like the CPAg, successful candidates can use their credentials and the associated post nominals and logo as part of their communications and promotion.

CAg accreditation is by application only and requires membership of either AIA or another professional organisation such as the Agronomy Society of Australia or Crop Consultants Australia. There are costs involved in applying for and retaining accreditation however the process of application has been described by CCA participants as the 'equivalent of filling in a detailed job application.'

CCA Director and long-term member David Kelly is an Agronomist with MacIntyre Independent Agronomists based in Goondiwindi. David recently obtained his CAg accreditation and was happy to share his thoughts on the process.

David feels that the accreditation gave him the opportunity to gain recognition for the professional development in which he had invested so much personally and monetarily. He also believes that it brings a point of difference to his business. In the future he is hopeful it will give him the ability to take on more diversified work that might require such accreditation as either part of the due diligence of the client, or as a prerequisite to the role.

'It also gives you the incentive to push on with ongoing professional development to retain the accreditation in the future', he said.

Despite the business advantages that the CAg scheme brings to David, he is keen to encourage anyone who might be interested in accreditation to 'give it a go.'

"It would be great to see more members of the industry get involved to build the strength and recognition of the programme," he said.

"It is vital that we continue as an industry to build our reputation for professionalism and accountability. We need to be an industry in which the wider community can have confidence."

For more information on the schemes visit: www.aginstitute.com.au

MAKE SOIL TESTING THE NEXT STEP

In 2020, soil testing will continue to be important for a range of reasons, such as:

Guiding recovery from fire or drought conditions

A grassfire can change the fertility of the soil in the short term. Elements such as potassium can become more available and the amount of nitrogen is generally reduced. Drought conditions can also affect soils. Nitrogen and phosphorus levels may be elevated in the topsoil, but then this topsoil may be lost due to erosion. Soil testing can show what's happening with soil fertility and help guide fertiliser choices that will promote pasture and crop establishment.

Assessing the soil fertility impacts from hay cutting or rotation changes

Significant changes may be taking place in soils where growers are altering their rotations and more frequently cutting hay. Checking the soil fertility by soil testing will help guide fertiliser programs for the coming season and for long-term sustainability.

Identifying an appropriate starter phosphorus rate where budgets are tight

Soil testing reduces the risk associated with cutting rates when times are tough. But before making any decisions, growers should arrange soil testing to get an up-to-date knowledge of the soil's phosphorus status. Where soil phosphorus levels are below recognised district critical levels, cutting back on starter fertiliser can limit crop yield potential.

Providing a basis for nitrogen and sulphur decisions at planting and throughout the season

Soil testing before sowing is the best way to quantify carry over nitrogen reserves from 2019 plus any mineralisation over summer so that an appropriate fertiliser strategy can be developed. Soil test results provide the information needed to take action based on real data. It's a similar story with sulphur, which can also be supplied at sowing or topdressed.

Above all, soil testing will allow winter crop growers and graziers to make informed fertiliser investment decisions and set crops and pastures up for success. If you are yet to start soil testing, the following advice may help you get the most out of it.

TIMING

Soil testing can be undertaken at any time, but if the ground is too hard and dry it may be impractical, especially for deep soil tests. It may be better to wait until after rain. This may allow for some nitrogen mineralisation to be captured in the results as well.

SURFACE TESTING

Phosphorus fertiliser investment decisions for 2020 should start with knowing or defining the soil phosphorus status from a surface soil test (0-10 cm). If the information is not available, soil test now to find out.

It is important to collect a good representative sample made up of 30-40 cores to accurately represent the paddock. In cropping, one of the main areas of phosphorus variability in the paddock is likely to be in the previous fertiliser band. If all the samples are taken from between the rows, the results are likely to come back lower than if all the samples are taken from within the previous fertiliser band. The equation to determine the right mix of samples is: Sample = row spacing (cm) x 0.262. For pastures, consider including some cores from high producing areas, around dung

Jim Laycock, Technical Agronomist at Incitec Pivot Fertilisers

and urine patches, to obtain a representative sample.

There can also be a wide variation in soil phosphorus levels across a single farm. By testing paddocks separately, phosphorus fertiliser rates can potentially be altered on 'paddock by paddock' basis. This may mean significant savings for farmers if some paddocks have a high enough base fertility to allow lower fertiliser rates to be used in 2020.

DEEP SOIL TESTING

Deep soil tests are primarily used for assessing how much nitrogen and sulphur are in the soil profile. Nitrogen levels can vary significantly from paddock to paddock depending on previous management strategies. Sulphur and nitrogen depletion can occur after wet weather due to leaching, so deep soil tests may be particularly valuable if there has been flooding.

Again, a representative sample is important. One test should be made up of six deep cores from a representative area of the paddock. Consider using yield maps, EM surveys or previous shallow soil tests to find a very uniform parcel of ground that represents a larger percentage of the whole property.

If segmented sampling is used, it can also show at what depth the nutrients are located. Segmenting samples into 0-10 cm, 10-30 cm, 30-50 cm and 50-70 cm increments can also assist in determining if and where there are any subsoil constraints, such as salt, sodium or boron.

QUALITY ANALYSIS

Look for a laboratory which offers recognised analytical methods related to interpretations for Australian agriculture. Ideally, the laboratory should participate in the ASPAC proficiency testing program and maintain a quality control system to AS/ISO 17025 standard through an authority such as the National Association of Testing Authorities. The Nutrient Advantage laboratory is committed to these quality standards.

Soil nutrition and soil health continue to be leading contributors to productive, high yielding crops and pastures, so why not make soil testing through the Nutrient Advantage laboratory part of your annual program? There is no better way to accurately assess soil fertility and nutrient availability than to soil test.

It has been good to see an influx of soil samples at the Nutrient Advantage laboratory over the past two months, as many winter crop growers and graziers begin working on establishing a solid foundation for next season's fertiliser program.

COTTON RETURNS TO BRISBANE VALLEY FOR THE FIRST TIME IN 60 YEARS

A mixed operations farmer from Queensland's Brisbane Valley has grown a cotton crop this season in what's believed to be a first for the region in 60 years.

Mark Cowley is a third-generation farmer at Toogoolawah. His grandfather used to grow cotton back in the 1940-50s before the family moved into dairying and pigs.

When the economic effects of deregulation began to bite in 2003, the Cowley's stopped dairying.

Since then, Mark has grown a range of crops, particularly pumpkins and peanuts, and farmed livestock.

"We've always had a livestock footprint and the family has always had cattle," Mark said. "Five or six years ago we introduced pigs back into the place - free-range pigs working on rotation across our operation. We also try and grow a bit of stuff that puts back in to the soil - we grow a lot of pumpkin, peanuts, we used to make a lot of hay."

The Cowley's mixed farming enterprise is about 1,200 hectares in size, with different members of the family running properties that form the operation.

"My dad runs part of it, my uncle and cousins run bits of it too," Mark said.

Cotton's connection with the Brisbane Valley stretches back to at least 1870, when one of the earliest gins was built at Ipswich.

But after decades without cotton being grown in the valley, Mark decided this season was the right time to have a go at growing the crop.

"The climate of the valley suited cotton - I wanted to grow a crop that could handle the hot and dry," he said. "Corn's really not an option, it's too expensive to grow for the return; peanuts are the same - they've got too expensive and were no longer an option for us.

"So, I was looking to try something else - we needed something stable and reliable as far as returns are concerned.

"I'd spent a lot of hours on a cotton picker through he dry years here at home - I went out with a contractor and have been involved in planting, fertilising, picking and it was enough to get me interested in it.

"It got the better of me this year and I just did it."

Mark planted a small 14-hectare irrigated crop, which has grown well. He will pick the crop at the end of April.

He said he had learned a lot through the season to date and had already identified things to improve for next season.

"I'll incorporate cotton into our operation as a rotational crop - I think cotton has a pretty important place in a rotation," he said.

"We'll continue to grow a heap of different things, but it'll be on a rotational basis."

Mark said CSD and Cotton Grower Service Dalby had been very helpful in advising him on how to succeed in growing a crop and to understand the ins-and-outs of cotton production.

He encouraged others thinking of diversifying their operation to consider cotton.

"[If you think of the] horror stories of cotton from 30-40 years ago ... technology has changed and things have moved on. It's certainly a lot better place to be," he said.

"Don't be scared of it; if you want to have a crack at it, have a go."

Mark Cowley operates a mixed farming operation in Queensland.

PLANTS FOUND TO SPEAK ROUNDWORM'S LANGUAGE

Nematodes are tiny, ubiquitous roundworms that infect plant roots, causing more than $100 billion in crop damage worldwide each year. New research has found that plants manipulate the worms' pheromones to repel infestations, providing insights into how farmers could fight these pests.

Led by Boyce Thompson Institute faculty member Frank Schroeder, the group studied a group of chemicals called ascarosides, which the worms produce and secrete to communicate with each other. As described in a paper published in Nature Communications in January, the researchers have shown that plants also "talk" to nematodes by metabolising ascarosides and secreting the metabolites back into the soil.

"It's not only that the plant can 'sense' or 'smell' a nematode," Schroeder said. "It's that the plant learns a foreign language, and then broadcasts something in that language to spread propaganda that 'this is a bad place'. Plants mess with nematodes' communications system to drive them away."

The study built on the team's previous work showing that plants react to ascr#18 - the predominant ascaroside secreted by plant-infecting nematodes - by bolstering their own immune defences, thereby protecting them against many types of pests and pathogens.

In those earlier studies, "We also saw that when ascr#18 was given to plants, the chemical disappears over time," according to lead author Murli Manohar, a senior research associate at BTI.

That observation, along with published literature suggesting plants could modify pest metabolites, led the team to hypothesise that "plants and nematodes interact via small molecule signalling and alter one another's messages," Schroeder said.

To probe that idea, the team treated three plant species - Arabidopsis, wheat and tomato - with ascr#18 and compared compounds found in treated and untreated plants. They identified three ascr#18 metabolites, the most abundant of which was ascr#9.

The researchers also found Arabidopsis and tomato roots secreted the three metabolites into the soil, and that a mixture of 90% ascr#9 and 10% ascr#18 added to the soil steered nematodes away from the plant's roots, thereby reducing infection.

The team hypothesised that nematodes in the soil perceive the mixture as a signal, sent by plants already infected with nematodes, to "go away" and prevent overpopulation of a single plant. Worms may have evolved to hijack plant metabolism to send this signal. Plants, in turn, may have evolved to tamper with the signal to appear as heavily infected as possible, thereby fooling would-be invaders.

"This is a dimension of their relationship that no one has seen before," said Manohar. "And plants may have similar types of chemical communication with other pests."

Although the mixture of ascr#9 and ascr#18 could serve as a crop protectant, Schroeder said there should be no detriment to using straight ascr#18 on crops, as described in the team's earlier research.

"Ascr#18 mainly primes the plant to respond more quickly and strongly to a pathogen, rather than fully inducing the defensive response itself," he said. "So there should be no cost to the plant in terms of reduced growth, yield or other problems."

The team also showed that plants metabolise ascr#18 via the peroxisomal β-oxidation pathway, a system conserved across many plant species.

"This paper uncovers an ancient interaction," Schroeder said. "All nematodes make ascarosides, and plants have had millions of years to learn how to manipulate these molecules."

He added: "Plants aren't passive green things. They are active participants in an interactive dialog with the surrounding environment, and we will continue to decipher this dialog."

These tomato roots have been infected with southern root-knot nematodes (Meloidogyne incognita). The microscopic roundworms form galls or "knots" where they feed, ultimately stunting the plants and reducing yield. Photo credit: BTI/Murli Manohar

Journal Reference:

Manohar, M., Tenjo-Castano, F., Chen, S. et al. Plant metabolism of nematode pheromones mediates plant-nematode interactions. Nat Commun 11, 208 (2020) doi:10.1038/s41467-019-14104-2

Paradigm®
Arylex® active

HERBICIDE

Paradigm® Arylex® active Herbicide is now registered in fallow, helping keep valuable moisture and nutrients in the soil.

- Widely compatible with glyphosate, Garlon® 600, 2,4-D amine and Starane® Advanced.
- Short to moderate soil persistence which will aid in the management of surface germinating weeds
- Short re-cropping periods to cereals

For more information 1800 700 096

CORTEVA™ agriscience

Visit us at **corteva.com.au**